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55th Annual Meeting

MINNEAPOLIS, MINN., June 18–21, 1947

Host

UNIVERSITY OF MINNESOTA

A Report to the Membership

By EARLE B. NORRIS

Vice President for General and Regional Activities

Your President should be making this report but he is, I hope, enjoying one of those almost forgotten things known as a vacation somewhere up among the 10,000 lakes of Minnesota. And so he has sent word by our omnipotent Secretary that I am to prepare an "editorial" for the October issue of the JOURNAL.

I have neither the propensity nor the desire to editorialize in the accepted sense of the word, but I do feel that some form of report to the members of A.S.E.E. might be in order.

THE NEW CONSTITUTION

In June we adopted a new constitution as well as a change in name. I was one of the rank and file of the Society who was somewhat bewildered by the apparent complexity of the organization outlined by the new constitution but who had faith in the group of stalwarts who had labored so faithfully in the task of revision. So, like the rest of you, I voted for the new constitution, but wondered if it was going to work. Since then, as one of the officers, I have familiarized myself with the constitution prehaps more thoroughly than most of the members. Your Executive Board, made up of the President, the four Vice-Presidents, the Secretary and the Treasurer, has held one meeting. From this limited but satisfying experience I can report my firm belief that our constitution and the organization which has thereby been created is going to work smoothly and effectively.

THE GENERAL COUNCIL

The constitution specifies that the General Council of the Society shall consist of certain of the officers and three Past Presidents and *"a representative of every Division and Section,* elected by the body concerned for a term of two years according to a plan of rotation in which one-half of such representatives will be chosen each year."

The Secretary informs us that reports are coming in very slowly on these selections of members of the General Council. If the council is to be truly representative, these representatives should be chosen promptly and the Secretary notified of the action. In many cases, the Sections meet but once a year, often in the Winter or early Spring. To wait for such meetings would delay the organization of the Council. It is, therefore, requested that the officers of each Section arrange promptly for the selection of a representative to be a member of the Council.

A TEACHING MANUAL

The Division on Electrical Engineering at its meeting in St. Louis suggested that the Society should publish a manual on good teaching for general distribution to the membership

and, especially, for the guidance of the hundreds of new teachers who will be employed this fall.

In the meantime, attention has been called to the existence of such a manual, entitled "Effective Teaching," prepared by a committee of the Engineering Faculty of the Virginia Polytechnic Institute and published by that institution. Mention of this Bulletin was made in the June issue of the JOURNAL OF ENGINEERING EDUCATION.

The Executive Board of the Society considered this matter at its July meeting and recommended that the V.P.I. bulletin be suggested to those Schools of Engineering which feel the need for such a manual. Already over 5,000 copies have been sold and the remaining supply is getting low. V.P.I. will make a third printing if there is sufficient demand to justify it. We do request that future orders be placed by the institutions in quantities as needed and thus lighten the burden of mailing individual copies. With assurance of financial assistance by the Society, if necessary, we will continue the former price of 10¢ per copy in spite of increased printing costs. Purchase orders may be sent to—

Office of Publications
Virginia Polytechnic Institute
Blacksburg, Virginia.

The order should specify "Engineering Extension Bulletin No. 42—Effective Teaching."

TEACHING PERSONNEL

It is presumed that all deans of engineering are informed of the possibilities of locating competent engineering and science teachers through the lists of the Office of Scientific and Specialized Personnel, Department of Labor, and of the Scientific Personnel Division, Office of Research and Inventions, Navy Department, Washington, D. C. Notices of these services were sent out by Mr. H. H. Armsby, of the U. S. Office of Education. Those who have tried it have found these offices very helpful in locating teaching talent. We should do more of it. Hiring teachers from each other is fine for the teachers, but it does not increase the overall supply. We need to bring in more men from the outside and getting these people who are being released from the Government Services is the most effective way.

Minutes of Meeting of Executive Board, A.S.E.E.

A meeting of the Executive Board of the American Society for Engineering Education was held in the University Club, Pittsburgh, Pa., on July 20, 1946, with all members present—H. O. Croft, *Chairman,* F. M. Dawson, C. J. Freund, J. R. Killian, E. B. Norris, J. S. Thompson and F. L. Bishop.

The minutes of the meetings of the Council in St. Louis were read.

A committee on basic scientific degrees, authorized in the above minutes, will not be appointed until we have further information concerning the matter.

The Secretary is to confer with Mr. Monteith of the Westinghouse Electric Corporation re the Lamme award. $175.00 needed for a change in the die of the medal; $2,000.00 would probably make the fund self-supporting.

Mr. Killian is to be sent a breakdown of expenditures of the Administrative Division last year.

Letters to accompany bills for dues to institutional members read and approved.

Motion passed that until the amalgamation of the E.C.R.A. and A.S.E.E. has been completely effected the parent Society should not pay any funds to E.C.R.C.

We are to invest $5,000.00 in government bonds from surplus account. The Treasurer was authorized to make such investment of the life membership fund as he deems appropriate and the balance to be kept in a separate account—$1,000.00 decided upon later.

Moved that a study be made of the possibility of including in the JOURNAL OF ENGINEERING EDUCATION all material which is now published in the *Civil Engineering Bulletin* and the *Journal of Engineering Drawing.*

The request from the Civil Engineering Division for $158.00 was approved with the understanding that this does not presume a continuation in the future.

A manual on good teaching was referred to the E.C.A.C.

21 applications for individual membership approved.

Messrs. Hudson and Thompson, Dept. of Commerce, reported $1,500,000 for industrial research. They came to acquaint the Board with the plan of the Commerce Dept., and to bring to our attention the fact that this fund is available for research problems. They want suggestions that will aid in making this plan more constructive. Vice President Dawson will give them information as to whom they should contact in engineering colleges. The Society invited to participate as a body. Matter referred to E.C.R.C.

Pins and charms. We are to ask Whitehead and Hoag if there is any commercial value in the pins and charms remaining of S.P.E.E. Motion that we appoint a committee on design of pin, charm and certificate.

This Board especially commends the activities of the Committee on Relations with Industry, under the chairmanship of A. R. Stevenson,* and urges that this activity be continued and expanded.

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* Deceased August 28, 1946

Rotation of members of the Council. It was agreed that divisions and sections should be arranged alphabetically and the representatives on Council would be: first, 1 year; second, two years; third, 1 year. . . .

Members of Council appointed pro tem from sections approved.

The invitation from the University of Minnesota to meet in Minneapolis was accepted and the dates set as June 18, 19, 20, 21, 1947, inclusive—Wednesday through Saturday.

It was the sense of the Executive Board that this was not the year for E.C.P.D. to make re-inspections unless institutions invited same. The suggestion is to be passed on to our representatives on E.C.P.D.—H. S. Rogers, W. R. Woolrich, and D. B. Prentice.

A committee on safety is to be appointed.

Ohio Northern University and Scranton-Keystone Junior College were dropped for non-payment of dues.

Action on surplus property referred to E.C.A.C.

Motion that the President continue the Committee on Outlook in Demand and Supply of Engineering Graduates with the same personnel but that R. M. Kimball be made a member. The Committee is K. T. Compton, *Chairman*, M. T. Carpenter, F. M. Dawson, O. W. Eshbach, E. V. Hollis, S. C. Hollister S. C. Lind, C. T. Reid, Thorndike Saville, G. B. Thomas, M. W. Trytten, H. H. Armsby, R. M. Kimball.

The Secretary was instructed to write for dates of meeting of the Engineering Section of the Land Grant College Association. (December 16–18, 1946.)

Motion that there be a meeting of the Council of the A.S.E.E. and of E.C.A.C. at the time of the above meeting in Chicago.

It was suggested that the Secretary make an outline of general sessions and conferences for the 1947 meeting.

The Vice Presidents are to serve as follows: E. B. Norris, 1 year; C. J. Freund, 2 years; J. R. Killian, 1 year; F. M. Dawson, 2 years.

The meeting adjourned at 3:35 P.M.

Respectfully submitted,

F. L. BISHOP, *Secretary*

Report of the Secretary, F. L. Bishop, 1945-46

Membership. We now have the largest membership in the history of the Society, 3,989 individual and 170 institutional members, a grand total of 4,059. We have lost 28 members by death; 93 have been dropped, and 62 resigned. We have elected 391 this year.

During the past year, three of our members, representing the Society, visited foreign countries—J. S. Thompson, South America; S. S. Steinberg, Central and South America; and E. P. Hamilton, Australia. It is interesting to note that since these trips the Society has added 25 new members from outside the United States and Canada. Interest in the Society in foreign countries has increased very much in the last year or so and, now that mail service to most of the foreign countries has been resumed, this office is receiving many letters from these countries. We not only receive requests for information on engineering education but for books for libraries, public and private; money to continue their education; names of persons with mutual interests with whom they may correspond; help to get into the country; etc.

Publications. We still have printing difficulties—lack of paper, lack of pressmen, all conspire to make it difficult to issue the JOURNAL on time. There are approximately 200 papers presented at the annual meeting. Cancellation of the 1945 meeting meant that this number of papers would not be available for the JOURNAL. An appeal to the members brought forth a very good response. We wish to take this opportunity to thank those who contributed papers for the JOURNAL this year.

Sections and Branches. Every Section and Branch has been active this year. We have a request for the formation of the University of Washington Branch so that they may become affiliated with the Puget Sound Council of Engineering and Technical Societies. This Branch is necessary since the Pacific Northwest Section of the Society covers Oregon, Idaho and Montana in addition to Washington. We also have a request that the UPPER NEW YORK SECTION be specified to include the State of New York with the exception of the metropolitan region.

The KENTUCKY Section, by unanimous vote of its membership, dissolved itself so that the members may participate actively in the Southeastern Section of the Society.

The SOUTHEASTERN Section has been unusually active and has secured a grant from the General Education Board of $30,000 for three years for the research activities of that group. R. C. Ernst, Chairman of the Scholarship Committee of that Section, will present a report on this work at this meeting.

Divisions. All divisions of the Society have been active. The ADMINISTRATIVE OFFICERS OF ENGINEERING COLLEGES held a meeting in Pittsburgh on December 7–8, 1945.

The CIVIL ENGINEERING Division continues to cooperate with a committee from the American Society of Civil Engineers in a study they are making.

The DRAWING Division is holding a

summer school at Washington University before and immediately after this annual meeting. Justus Rising, Chairman, and his committees have worked hard to make this school a success.

Awards. Since 1928, a gold medal, the Lamme Award, has been presented to an engineering educator at our annual meetings. The name of the recipient of the 19th award will be made known at our annual dinner by the Chairman, D. S. Bridgman.

This year, for the first time, the George Westinghouse Award in Engineering Education, $1,000, will be made. James Norman Goodier, Professor of Mechanics at Cornell University, will be the recipient. This award is made possible by a grant from the Westinghouse Educational Foundation to the Society. H. L. Dodge is Chairman of the Committee on Award.

Committees. The Committee on Outlook for and Supply of Engineering Graduates made a survey of enrolments and facilities of engineering schools this spring. The Chairman, K. T. Compton, will make a report at this meeting.

S. B. Elrod, Purdue University, has represented the Society on the S.A.E. Committee S–1. The S.A.E. has written the Secretary of its appreciation of the services which he has rendered to that Committee.

The Committee on Revision of the Constitution and By-Laws, appointed in 1944 by action of the Council, completed its task. The report was published in the April issue of the JOURNAL OF ENGINEERING EDUCATION and will be presented to the membership of the Society on June 22, 1946, for action. At the request of the Committee a straw vote on changing the name of the Society was taken. This, of course, is only a straw vote and should not be construed as a vote on changing the name of the Society. 2,674 members voted as follows:

American Society for Engineering Education	2,188
Society for Engineering Education	159
Engineering Educational Society	82
Society for Promotion Engineering Education	197
Unsigned or unmarked ballots	48
	2,674

On Teaching of Quality Control to Engineers

By LESLIE E. SIMON

Colonel, Ord. Dept., Director, Ballistic Research Laboratories, Aberdeen Proving Ground, Maryland

"There is a tide in the affairs of men,
Which, taken at the flood, leads on to fortune,"—

Shakespeare's Julius Caesar

ABSTRACT

A distinction is made between the training and attributes necessary for a quality control engineer and the minimum of training in statistical principles necessary to equip students properly as engineers. At present, the former is not amenable to undergraduate college curricula, whereas the latter is so essential to all prospective engineers that it may be an important contribution to the difference between decadence in the engineering profession and vigorous leadership in an increasingly scientific world.

The Field of Quality Control Engineering. Quality control engineering is sufficiently new and broad that confusion is likely to arise unless one defines the scope of the field he proposes to discuss. Strictly speaking quality control, in the Shewhart sense [1], pertains to the control of quality of product in the manufacturing process. More recently, and especially during the years of war production, quality control was broadened to include various techniques for the identification of quality of manufactured products after fabrication or at stages in the process of production. Whereas the latter may well be considered quality *determination*, rather than quality *control* (because little or nothing can be done to control or rectify the ills of the completed product), nevertheless the broader field is the one in which the quality control engineer will almost certainly be called upon to work. Consequently, it should be considered a part of quality control engineering from the viewpoint of training.

In the term quality control engineering, quality control is the genus and engineering is a differentia which narrows the field of quality control. Quality control includes devising and administering techniques to identify graduations in quality of manufactured products; technical assistance in isolating and removing causes of poor quality, sampling, sorting, and determining disposition of product. The applications of quality control engineering are continuous in character and revisions which bring about economic improvements are necessary from time to time in order to achieve maximum efficiency of operation. Thus, quality control engineering extends far beyond the application of routine procedure such as the control chart techniques. Persons can be adequately trained in an intensive course of eight days to perform many of the routine tasks connected with quality control, but the more or less routine functions do not constitute quality control engineering; adequate training necessarily requires

not only statistical and engineering competence but some practical experience in the field in which one is to work.

Limitations on the Teaching of Quality Control Engineering. Like the teaching of other branches of engineering, the teaching of quality control engineering suffers from incertitudes which arise from the many fields of endeavor in which the student may be called to apply his knowledge. For example, in the teaching of mechanical engineering, one cannot anticipate whether the student will apply his knowledge to the manufacture of automobiles, sewing machines or precision comparators. However, one can be reasonably sure that the student is not taking mechanical engineering in order to apply it to the production of smokeless powder, ordinary petroleum products, or to the production of high grade medicine such as penicillin. In the teaching of quality control engineering one lacks even this meager assurance. The quality control engineer may be called upon to work in almost any field of science or engineering which has to do with a product which admits of measurement. Consequently, it is difficult to prepare the student in a specific way for the practical aspects of his task. In teaching quality control engineering one can hope to supply the student with a kit of tools. His real education in the use of the kit of tools must begin with the task at hand. The best assurance that he will succeed in the practical test of his ability consists of cultivating a catholicity of interests, insatiable curiosity for knowledge, and habits of persevering application which are characteristic of the technical research worker. Moreover, the quality control engineer must constantly face such problems as to what quality is necessary for service use in order that he may produce an economic quality with existing plant equipment. Hence, the training of men for quality control engineering and the training that one looks for in a prospective worker in applied research are closely allied.

The Quality Control Engineer as a Variant. These are grounds for concluding that the quality control engineer is one who happens to stray from the beaten engineering path by becoming more interested in the statistical and critically interpretive side of his work than in the purely engineering side; or, on the other hand, he may be a mathematician, statistician, or physicist with strong engineering and economic interests. It does not appear practicable to establish curricula for quality control engineering. The fields are too varied; the qualifications too dependent upon a hybrid background or catholicity of interests. Therefore, the teaching of quality control to engineers should not have for its purpose the graduating of specialized quality control engineers. It should have for its purpose only the teaching of sufficient statistics to equip students properly as engineers. The graduate student who wishes to become a quality control engineer should seek additional training which will fit him for the particular field in which he intends to work.

The Engineer's Unfamiliarity with Statistical Methods. It seems strange that statistical techniques should be regarded by many engineers as differing fundamentally from or being inapplicable to (the remainder of) their work. Courses in statistics are normally included in the curricula of economics, sociology, marketing, agriculture, business administration, and biology. The mathematician, physicist, and astron-

omer generally have a background in statistics. Workers in these fields are no more concerned with sampling and the risks of interpreting sampling results than engineers. In speaking "On Training in Sampling" Dr. W. Edwards Deming [2] recently said "It is not widely enough recognized that in a professional job of sampling the risks, being controllable and known in advance, are tailored to the requirements of precision with efficient use of funds and facilities. This important feature of sampling needs to be taught by statisticians to their professional colleagues in other fields." It is indeed strange that engineers who are far more associated with efficiency, precision, and dollar practicality than their brethren in the field of social sciences, should tend to use judgment, opinion, and rules-of-thumb, while workers in these less exact fields find precision methods indispensable. The difference does not appear to be attributable to a difference in temperament in the men who enter the social sciences and the men who enter engineering fields; it must be due to not including essential courses in statistics in the curricula of engineering courses.

Teaching of Statistics Essential to the Future of Engineering. I do not believe it essential to discuss the merits of quality control. Its merits have been so dramatically demonstrated in the places where it has been applied that one wonders why it has not become universal in all engineering during the 22 years that it has been extant. The anomaly is rather easily explained. Some forward-looking person in a position of authority recognizes the advantages of quality control engineering. He acquires or trains some quality control engineer; puts quality control procedures into effect; and achieves excellent results. The engineers associated with the work accept the quality control regime in an unfriendly manner because it is new and because they regard it as differing from their usual kind of work. As time goes on, they force it by passive resistance into innocuous desuetude. Time and time again I have seen quality control flash as a meteor into a field of work, fade out, and become all but forgotten. In order for quality control to succeed in the engineering profession, either there must be fed into that profession constantly a stream of bright, energetic, and clever variants who will act continuously as an irritant on the body of the engineering profession or else *engineers must be taught quality control and other established techniques initially, so that they regard these powerful statistical tools as a part of their engineering profession.* The former alternative is difficult, unpromising, and inefficient. The latter is efficient and would improve the tone of all engineering activities. Quality control must come to engineering, or engineering simply will have failed to keep pace with the advance of science.

Quality Control Curricula for Engineers. The conclusion that the teaching of quality control to engineers is necessary to the advancement of the science of enginering would be incomplete without saying something about what should be taught and how it should be taught.

It may seem foreign or even pedantic to seasoned engineers, but education in statistics should begin at the beginning. The student must be taught the elementary classifications by attributes, class frequencies, dichotomies and manifold classification, random and systematic errors, independence, association, tests of consistency of data, of independence,

and measurement of association. Until recently [3], [4], [5], most text books were written from the viewpoint of sociology or biology, and one may be quite bored with the frequency of blue-eyed sons of brown-eyed fathers, the deaf, dumb, halt, lame, and blind, before he masters these elementary concepts. However, mastery of these elementary statistical concepts is essential if engineers are to cease their naive tendency to argue logically from scant data to invalid conclusions. The engineer may know that one swallow does not make a summer, but he is entirely unaware either of the uncertainty of an observed ratio c failures in n trials or of how great n should be in order to make his data valid for engineering use.

These concepts are also essential background to still more useful concepts of frequency distribution. The student should be thoroughly familiar with the more common distributions such as the binomial, normal, and Poisson, and at the same time understand thoroughly the limitations of their applicability to practical problems. He must know averages and other measures of location, and understand thoroughly measures of dispersion. It is common for an engineer to quote an average followed by a plus or minus figure without any indication as to whether the expression of dispersion is probable error, standard deviation, the range within which all results are expected to lie, or even the slightest indication of n (the number of trials on which the results are predicated). To the more precise analyst, this is shocking. A less tutored man would quote all the data; a physicist would at least quote the probable error; but the engineer if called to account, is likely to feel that one has impugned his engineering judgment, and is being meticulous about matters which are outside his field, and are unimportant anyway. As a concrete illustration of the costliness of this attitude, consider the linear assembly of two piece parts each of which is approximately normally distributed within an overall tolerance range of $\pm a$. At least nine engineers out of ten would believe that random assembly would require a tolerance range of $\pm 2a$, whereas the resultant tolerance range is only $\pm a\sqrt{2}$.

The engineer should know something of correlation, curve fitting, and be competent in the application of the more common statistical tests, such as the Chi-square, t, δ, and F tests [6]. He needs these things in order to make valid engineering judgments so that factors of safety may become, as the name implies, provisions for a region of variation so chosen as to reduce a calculated risk to the desired order of magnitude; not factors of ignorance to allow for technical incompetence.

This statement may sound drastic, so I would like to give an extreme illustration of a calculated risk factor. Just prior to World War II, it was discovered that very small scale manufacture of munitions during the peace had not furnished evidence of the likelihood of dangerous premature explosions of artillery shell when manufactured on a large scale by many producers. Colonel H. H. Zornig, former Director of the Ballistic Research Laboratory (now retired), was given the task of reducing the frequency of premature explosion of artillery shells (dangerous explosion near the gun) to an acceptable figure. This was a most complex engineering problem, involving the design and process of manufacture of the fuze, booster, explosive filler, metal and other parts of the shell, techniques for the detection of poor quality, procedures for the testing of modification in design, as well as a balancing of cost of and quantity of

production against risk. After careful investigation which involved many of the above statistical techniques, it was decided to attempt to meet a calculated risk of premature (explosion) which would be between 1/50,000 and 1/100,000. I have been recently informed orally that the Chief of Ammunition Division says that records indicate that the World War II premature rate was about 1/70,000. Such an achievement must involve some luck as well as skill, but it would not have been possible without the engineering use of quality control methods.

Elementary statistical methods are a part of the minimum background for an engineer's work in quality control: not just control of quality of product in process of production, but quality control in research, design, testing, development, and production. An elementary text book such as "An Introduction to the Theory of Statistics" by G. Udny Yule and M. G. Kendall [7] will cover practically all of them. When work is begun on research, design, or development, the individual who has had this elementary work will know enough to study further.

However, industrial process control is so important to engineers that a short course in process quality control should be included in the curriculum. This need not necessarily include the class-room study of a text book as long and difficult as Shewhart's "Control of Quality of the Manufactured Product" [1], but should be at least as extensive as that covered by American Standards Z1.1 and Z1.2 [8], and Z1.3 [9].

Finally, the engineering student should in some brief but effective way have brought home to him the importance of predictive nature of much of his work, and the dependence of probability predictions on the scientific method of hypothesis, experiment and test of hypothesis [6]. The present day engineer understands the first two of these steps, but fails on the third. An appreciation of the philosophy of one's work is essential to the enjoyment of it as well as to its best conduct. For engineering students, this phase of preparation might include also a study of such a book as C. I. Lewis' "Mind and the World Order" and at least a reading of selected papers such as Shewhart's "Contribution of Statistics to the Science of Engineering" [10].

The Scarcity of Engineers Who Know Statistics. I am no educator, and approach the task of speaking before this gathering of distinguished professional college teachers most humbly. In 1939 I persuaded the U. S. Civil Service to give a nation-wide examination for men who combined a knowledge of engineering and statistics. Results showed conclusively that engineers were generally not taught statistics. Because the Ballistic Research Laboratories needed men of this type, and because it was felt that the need would be much more severe in the event of war, the Ordnance Department decided to attempt a small scale training program. The laboratories tried teaching statistics to engineers and teaching ordnance engineering to statisticians on a basis of regular classes held as part-time job training.

Wartime Success of Quality Control Engineering. I think the success of the individuals was due more to the men selected than to the proficiency of the training, but the need for quality control in engineering is attested to by their progress. During the war, all of them held positions of importance or responsibility either as officers or civilians in our Armed Forces—Industry team. The effectiveness of these few men together with a few similar men drawn from industry and educational institu-

tions is largely responsible for the success of the Army [11] and Navy [12] quality control and sampling inspection programs. The influence of these programs on quality, quantity, and cost was sufficiently obvious to be a primary influence in leading the War Production Board to give its eight-day training course in quality control in the principal cities of the nation during the war as an aid to war industry.

The Future of Quality Control Engineering. A number of papers give account of the contributions of quality control engineering to the victory. However, the same things which contributed markedly to war production efficiency can contribute also to winning the peace. A notable heritage from the war is the American Society for Quality Control, which is comprised largely of wartime trainees. Most of these trainees, however, were taught only the mechanics of process quality control and sampling inspections. They would probably freely admit that their training is neither well rounded nor complete.

Many of these men are not well equipped to exploit the powerful tools of engineering to their fullest or to easily overcome the resistance of old-line engineers who regard quality control concepts as pedantic and foreign to their profession. The teaching of quality control to engineers by leading universities would be a powerful stimulus to this enterprising group, strengthen their position, and contribute to a degree of industrial advancement which would greatly facilitate the work of future young engineers who will be graduated from your courses with training which is abreast of the advance of science. If this opportunity is neglected, engineering will miss a most advantageous opportunity to extend its useful service to mankind, which is its highest purpose; and the science of engineering will suffer a grave liability of becoming laggard with respect to other fields.

"Omitted, all the voyage of their life
Is bound in shallows and in miseries."

Shakespeare's Julius Caesar

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The Co-operative System—A Manifesto

By Committee on Aims and Ideals of Cooperative Engineering Education,
C. J. Freund, Chairman

There has been no lack of responsible discussion of the cooperative plan. Competent engineers and educators have lectured and written extensively on the subect, the several cooperative institutions have published their respective aims and standards, and a section of the S.P.E.E. Report of Investigation of Engineering Education is devoted to the system.

But the cooperative colleges have not heretofore associated themselves in order officially to formulate and publish their doctrine or creed. It seems proper for them to do so in order:

1. To inform engineers, educators, students, employers and the public concerning the cooperative plan.
2. To serve as a code for the guidance of their own officials and faculties.
3. To serve as a code for the guidance of the officials and the faculties of institutions which propose to experiment with the cooperative method, lest blunders prevent their success and discredit the method and the institutions where it is established.
4. To gain for the plan the full maturity and prestige which accrue to a movement or undertaking when, and only when, its aims and plans have been made public.

Definition

Just what is a cooperative college or school of engineering? For the purpose of this report, a cooperative college or school shall be one:

1. In which curricula lead to the bachelor's degrees in engineering, or to both bachelor's and higher degrees.
2. Which requires or permits all or some engineering students to alternate periods of attendance at school or college with periods of employment in industry during a portion or all of one or more curricula.*
3. In which such employment is constituted as a regular, continuing and essential element in the educational process.
4. Which requires such employment to be related to some phase of the branch or field of study in which the student is engaged.
5. Which expects such employment

Motion made and carried that this report be accepted and adopted by the Cooperative Engineering Education Division of the Society as the official statement of policy for the Division and the cooperative institutions which are members of the S.P.E.E. (now A.S.E.E.), and that the Editor be requested to print this report with a copy of this resolution in The Journal of Engineering Education.

* Certain institutions were forced temporarily to discontinue cooperative employment because of war conditions.

to be variegated in order to afford a spread of experience.

6. Which specifies minimum hours of employment, and a minimum standard of performance in such employment, among the requirements for a degree.

This definition includes a number of institutions which have not generally been recognized as cooperative, either by the public or, perhaps, even by themselves. In the popular conception, only those institutions are cooperative in which the cooperative method is sharply emphasized both in policy and in publicity.

Ultimate Educational Aims

The cooperative college is not distinct from others as far as its ultimate purposes are concerned. Both cooperative and non-cooperative colleges seek identical ultimate educational aims. What are these aims? In June, 1944, Robert E. Doherty pointed them out in the course of his presidential address before the S.P.E.E. when he stated that the finished product of engineering education should be "an educated man who can take his place in the community among members of other learned professions; who has *mastered* the essential body of higher learning that underlies his profession including a live knowledge, sufficient for good citizenship, of the world in which he lives; who has learned to think critically and constructively in terms of that knowledge, who has mastered the engineering method; who has cultivated to the utmost his creative talents; who has a professional consciousness and lives by it; who has travelled the Second Mile, and who plays the part of a leader in civic affairs. That is the kind of man we should visualize when we are planning engineering education. . . ." *

The S.P.E.E. Committee on Aims and Scope of Engineering Curricula formulated the ultimate scientific-technological aims of engineering education as follows:

"1. Mastery of the fundamental scientific principles and a command of basic knowledge underlying the branch of engineering which the student is pursuing. This implies:

a) grasp of the meaning of physical and mathematical laws, and knowledge of how they were evolved and of the limitation in their use;
b) knowledge of materials, machines, and structures.

"2. Thorough understanding of the engineering method and elementary competence in its application. This requires:
a) comprehension of the interacting elements in situations which are to be analyzed;
b) ability to think straight in the application of fundamental principles to new problems;
c) reasonable skill in making approximations, and in choosing the type of approach in the light of the accuracy required and the time available for solution—in sum, a foundation for engineering judgment;
d) resourcefulness and originality in devising means to an end;
e) understanding of the element of cost in engineering and the ability to deal with this factor just as competently as with technological factors.

* Journal of Engineering Education, Vol. 35, September, 1944, p. 12.

"3. Ability to select the significant results of an engineering study and to present them clearly and concisely by verbal and graphic means.
"4. Stimulation of a continuing interest in further professional development." *

And the Committee on Aims and Scope of Engineering Curricula formulated these ultimate humanistic-social aims of engineering education:

"1. Understanding of the evolution of the social organization within which we live and of the influence of science and engineering on its development.
"2. Ability to recognize and to make a critical analysis of a problem involving social and economic elements, to arrive at an intelligent opinion about it, and to read with discrimination and purpose toward these ends.
"3. Ability to organize thoughts logically and to express them lucidly and convincingly in oral and written English.
"4. Acquaintance with some of the great masterpieces of literature and an understanding of their setting in and influence upon civilization.
"5. Development of moral, ethical, and social concepts essential to a satisfying personal philosophy, to a career consistent with the public welfare, and to a sound professional attitude.
"6. Attainment of an interest and pleasure in these pursuits and thus of an inspiration to continued study." †

The S.P.E.E. Committee on Engineering Education after the War reaffirmed these scientific-technological and humanistic-social aims formulated by the Committee on Aims and Scope of Engineering Curricula, ‡ and the Society approved the aims by adopting the reports of both committees.

The cooperative colleges of engineering accept and fully subscribe to these aims, and declare them to be their own.

Specific Aims of the Cooperative Method

There are, in addition, certain auxiliary purposes which are peculiar, or at least especially appropriate to the cooperative institutions, and which serve as means to the ultimate ends of engineering education. These auxiliary purposes are the following:

1. To impart first hand and actual knowledge of and experience with the execution in industry of engineering designs, projects and developments.
2. To impart understanding of and familiarity with the problems and the viewpoints of workingmen and women.
3. To assist students, by direct and personal experience in industry, to test their aptitude for engineering careers.
4. To enable engineering students to adjust themselves to engineering employments by gradual and easy transition from academic pursuits and mode of life to the requirements and conditions of industry.
5. To train and otherwise prepare students especially and directly for the administrative and operating functions which, to a greater

* *Ibid.*, Vol. 30, New Series, March, 1940, p. 564.
† *Ibid.*, Vol. 30, New Series, March 1940, pp. 563–4.
‡ *Ibid.*, Vol. 34, May, 1944, pp. 592 and 594.

or less degree, enter into most engineering careers.

These do not and could not possibly include all the particular aims of all the cooperative colleges. Individual institutions quite properly may and do seek additional purposes which are appropriate to their type of student, neighboring industries or other peculiar requirements or circumstances. The purposes here announced are only those which are common to the cooperative schools and upon which they can and do agree.

The special purposes will now be considered more in detail:

To Impart First Hand and Actual Knowledge of and Experience with the Execution in Industry of Engineering Designs, Projects and Developments

Educators and even the man in the street have always understood that engineers, and, indeed, all professionals, must have practical experience, and successful practicing engineers have insisted upon a period of apprenticeship following graduation from engineering college. But the great majority of graduates evaded apprenticeship because considerable prestige attaches to office work in the United States, as compared with any kind of manual or semi-manual employment, and because, as Mr. E. F. DuBrul has explained, "the average graduate on leaving college is of an age and habit of mind that prevent him from going back to learn the elementary things of the practical and business side of his career. He is ashamed to ask the foolish questions that alone draw out the knowledge possessed by others.*

But what, precisely is meant by practical experience?

The cooperative student is not expected to become a skilled machinist, draftsman, furnace operator or electrical repairman. Neither is he expected to gain experience, for instance, in every phase of mechanical power generation, power transmission, and in every department of metal working and fabrication; indeed, it has never been demonstrated that he needs to.

Nor does the cooperative student have to integrate closely instruction in the college and the application in industry of what he has just been taught; if he has learned how to design a riveted joint he need not immediately thereafter go to work with a steel erection crew.

What is intended is that the student be schooled in the "art" of engineering. According to Dean H. P. Hammond and his Committee on Engineering Education after the War, "Knowledge of . . . (the subject matter of engineering study) . . . does not constitute ability to practice engineering. There remains the necessity for the young engineer to integrate the application of these laws, assumptions, data and codes so as to accomplish a desired result safely and economically. This requires a combination of resourcefulness, skill, experience and judgment—amounting at times almost to intuition—which we call the *art* of engineering." †

What is intended is that the cooperative student shall learn how science is

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* "A Young Instructor and His Big Dreams," *American Magazine*, Vol. 68, May, 1909, p. 18.

† Journal of Engineering Education, Vol. 34, May, 1944, pp. 598–9.

actually applied in his profession and in industry; that he shall learn how engineering designs and plans are executed; that he shall become familiar with machines, structures and equipment by use and observation, and with their construction, capacities, limitations, standards, power, maintenance, cost, useful life, operating methods and practices. A young man may have complete mastery of thermodynamics and of the mutual relations of heat and power, and of the mathematical and physical laws underlying these relations, but he is hardly a finished engineer until he knows just how an internal combustion engine, for instance, is designed and built in order to convert heat into useful work, until he knows how the engine operates because he has himself worked with the carburetor, the combustion chamber, the ignition, lubricating and cooling systems; until he knows not only why, but in some detail *how* heat converts to work.

An illustration may be drawn from the profession of medicine. A man may be an authority in the sciences of anatomy, physiology, histology and embryology, but he is not qualified to practice medicine, to heal and to cure, until he has learned the proved methods, techniques and standards of his profession. All these he learns, not in scientific courses but by attending clinics and by himself treating and caring for patients as an interne under supervision.

Production conditions and requirements are an important element in the cooperative student's practice work. He may be finishing gears on a turret lathe. The gears are to become parts of machines made in the plant. He is one of a coordinated manufacturing team of hundreds or thousands. If he fails, the entire manufacturing scheme is disturbed. This is serious business. It forces him to recognize a type of responsibility which cannot be imposed in the college laboratory.

Finally, cooperative employment makes the student conscious of the active, the doing and making character of engineering. Engineering is not pure science; the end result of engineering effort is goods and commodities, not merely learned reports. As. H. E. Dyche and R. F. Hellmund have expressed it, ". . . the engineering profession is primarily a profession of creation and accomplishment, and the training of engineering students and of younger engineers therefore should be directed toward developing in them above all else a desire and ability to create and accomplish . . . accomplishment through knowledge rather than knowledge itself should be stressed throughout the entire course, beginning even in the undergraduate program as far as possible.*

To Impart Understanding of and Familiarity with the Problems and the Viewpoints of Workingmen and Women

A generation ago the engineer was not especially interested in labor except as a cost item. But much has happened during that generation. A sharp revision of the nation's attitude has created more sympathy for working people and has invested them with a greatly enhanced dignity. And the rise of the C.I.O. and the resurgence of the older unions have not only given

* "The Pitt-Westinghouse Graduate Program," *Electrical Engineering*, Vol. 53, January, 1934, p. 104.

organized employees vastly more power and influence in the control of industry than they ever before possessed, but have also immeasurably complicated industrial management, and have created a thousand labor problems where only one existed before.

There is abundant evidence that a majority of engineering graduates sooner or later become administrators or supervisors. As such, they must be acquainted with all the familiar industrial types: owners and officials, technical experts, managers, superintendents, foremen, technicians, artisans, mechanics, skilled operators and common laborers. The engineering student can read books about all these, but he will learn much better at first hand, by working with the men and women of industry, knowing them, living with them, being their friends, being one of them. The best preparation for leadership is for a time to be subordinate.

The cooperative student does all of this. The Report of the Investigation of Engineering Education states, "that the cooperative plan provides a means for acquainting the student with the importance of the human element in practical affairs. Periods of industrial experience should give the student an insight into the reactions and point of view of working men and thus equip him better to deal with the labor problems which he is likely to encounter in later years.*

The cooperative student should easily acquire the engineer's characteristic strength and ruggedness of character. Engineering work is nothing for weaklings; it is frequently strenuous. Dean Schneider believed "that a goodly amount of physical work in contact with those whose lot it is to labor should be required of every young man in his formative years, no matter what his position in life is, or is to be. Especially should it be required of engineers. Strong men have always grown stronger and better through this contact and competition, and the weaker find their levels more quickly than in any other way.*

To Assist Students, by Direct and Personal Experience in Industry, to Test Their Aptitude for Engineering Careers

Every engineering student must at some time or another determine for himself whether or not he belongs in the engineering field. Success in engineering study unfortunately does not constitute a final criterion of engineering aptitude. The engineering student may be quite happy in the engineering college, and just as unhappy afterwards in the industry for which he prepared. He may be altogether competent to solve the small, though often difficult problems which he encounters in his courses in structures, machine design, electronics or processes, but that does not prove that he can join a great team of engineers, technicians, mechanics, accountants, researchers, and officials in solving the vast and complicated problems of modern industry.

There is a wide difference between every day life and conditions of the college and of engineering industry. The college stresses intellectual attainments. Tasks are imposed upon the individual,

* Society for the Promotion of Engineering Education, Pittsburgh, 1929, Vol. I, p. 609.

* "Notes on the Cooperative System," *American Machinist*, Vol. 33, Part 2, p. 149.

not upon a group, in most cases. The problems are limited in scope, although they may not be easy. There is little pressure upon the students for results, although they will think there is.

College buildings, grounds and environment are usually gracious and frequently beautiful. The atmosphere is one of composure, ease and comradery.

Industry, on the other hand, stresses the moral and physical qualities rather more than intellectual capacity. Projects and plants are often so extensive that the young engineer's part in the operation is comparatively insignificant, and he is lost among hundreds or thousands of fellow workers. There is constant tension, and nervous demand for concrete results. There may easily be much noise, and perhaps even some dust, smoke, gas or extreme heat and cold.

The student must not merely know that he can perform engineering work; he must likewise know that he is temperamentally fitted for the environment of industry, and that his enthusiasm for the essentials of his work will outweigh features of working conditions which may be somewhat less than ideal.

The cooperative plan is a good test of the sum total of engineering aptitude. While the college classes measure the student's reasoning power, his capacity for thinking through a problem and his total intellectual qualification, practical work measures his ability to find his place in a complicated organization and to adjust himself to work and life as they are found in the industries. Neither college studies nor industrial employment alone can prove a student's engineering aptitude; but he can prove his aptitude by combining studies and industrial employment in the cooperative method.

To Enable Engineering Students to Adjust Themselves to Engineering Employments by Gradual and Easy Transition from Academic Pursuits and Mode of Life to the Requirements and Conditions of Industry

Even those engineering graduates who are naturally adapted to an engineering career encounter a problem in the sharp contrast between the conditions of college and of industry. This problem contains two elements: obtaining suitable employment in the first place, and getting used to the new environment.

Dean R. C. Disque has pointed out that the cooperative system serves ". . . to adjust the student quickly and effectively to his post-graduate job. This has been and still is the characteristic objective of the cooperative courses which have been uniformly extended to five years in order to achieve this objective." *

The cooperative system enables the employer more deliberately and thoroughly to select those engineering graduates whom he will permanently employ. The usual, fully organized procedure for the employment of engineering graduates involves preliminary correspondence, the filing of an elaborate application, possibly an aptitude test of some kind or other, and an interview of ten or fifteen minutes in which the applicant cannot possibly deport himself normally because so much is at stake.

On the other hand, the cooperative student spends half time for as long as four years in the employer's organiza-

* "Extension of the Engineering Curriculum and its Relation to Cooperative Work," Journal of Engineering Education, Vol. 31, May, 1941, p. 698.

tion, and the employer has abundant opportunity to observe his technical ability, his resourcefulness, his diligence, his reliability, and any other qualifications and characteristics which he may consider important. Except to train graduates for special tasks and functions, the cooperative employer requires no schools for the indoctrination and adjustment of graduates, no complex interview and selection procedure, no tours of inspection, no pep talks, no succession of checks and reports. The cooperative graduate reports on the morning after commencement, hangs up his coat and hat and goes directly to work. If he has been properly supervised during his employment periods, he should immediately become a producer, not merely an investment.

So much for the employer's problem. It appears to be quite typical of recent engineering graduates to be restless and unhappy, to seek transfers from office to shop or from shop to office, from sales to research, from production to design, from experiment to production; to negotiate for jobs in distant cities and even in foreign countries. The cooperative student, however, in the words of Charles F. Kettering, "is given the entire time of four years, three years, or two years, depending upon the particular cooperative program, in which to become acquainted gradually with the problems he must meet on the outside rather than confronting him suddenly with all the problems of adjustment when he graduates from school. By means of cooperative education he is given a transition between normal life at the university and the life he would live when he works in an industry." *

The cooperative student learns to expect the most elaborate designs and plans to be upset when an official of his own company or a customer suddenly changes his mind. He expects men to lose their tempers, to be inconsistent, forgetful, unreasonable and unjust. He expects the uneducated to be suspicious of him and the educated to require too much of him. But he likewise learns that the sum total of good qualities in the great majority of men and women very much more than compensates for their deficiencies.

He learns the very important and apparently very difficult lesson that countless ideal technological designs have been and constantly are discarded because it does not pay to manufacture, sell, build or operate the device or structure in question.

The cooperative student is likely to acquire a proper modesty. There probably never were as many inflated bachelors of engineering as unsympathetic critics of engineering education maintained, but there have been a few. There should be practically none among cooperative graduates. Dean Schneider contended that a cooperative student "in a large organization or on the building of a bridge learns quickly how little he knows. He gets the value of clear-out knowledge as against fluid generalizations. His perspectives begin to lose their distortions." * Long before he graduates he has learned his place in the scheme of things.

Finally, the cooperative student should win the respect of his fellow employees. The rank and file of industrial employees always resent an upstart. This resentment against the young man and the newcomer has

* "A New Approach to Engineering Education" (Tributes to Dean Schneider), University of Cincinnati, 1938, p. 1.

* Thirty Years of Educational Pioneering," University of Cincinnati, 1935, p. 16.

probably been an important cause of rather frequent tensions between college graduates and other employees. The cooperative graduate avoids much of the difficulty. He has been one of the employee group for some years; on a part time basis, indeed, but they may not even know that. He is known among them and he has friends among them unless he has been especially awkward in his relations with them. They have seen him perform difficult and sometimes more or less repulsive tasks. And when he is given a responsible and important job, they are disposed to grant that he is entitled to it.

To Train and Otherwise Prepare Students Especially and Directly for the Administrative and Operating Functions Which, to a Greater or Less Degree, Enter into Most Engineering Careers

There is abundant evidence that the majority of engineering college graduates sooner or later become engaged in supervisory or administrative duties. The S.P.E.E. Report of Investigation of Engineering Education indicates that 63.9 per cent of older engineering graduates are administrators. Most of them, however, are in charge of research, development, experiment, design and drafting, production and other specifically technological functions; they less frequently become general managers, vice-presidents, presidents and board members. W. E. Wickenden has pointed out why the average engineering graduate fails to reach the upper levels of management: "He is likely to be factual, quantitative, analytical and impersonal in his modes of thought; his capacity for judicial thinking, based upon concrete evidence, is usually less well developed; and his intuitive faculties, as a rule, have been so overshadowed by his analytical habits, that he often fails to sense the reactions of ordinary people. He is usually too forthright for adroit politics or suave diplomacy, and when he ventures amid the subtleties of human nature, he risks seeming callow and naive." *

It would be futile to attempt here to interpret the vast amount that has been published and reported on the requisite qualifications of the industrial executive and administrator. It will be much more profitable to suggest that the deficiencies to which Dr. Wickenden has called attention are necessarily inherent in engineering training because materials, forces, dimensions and quantitative methods are the object of engineering work. These deficiencies cannot be corrected in college; they can possibly be corrected by daily work and contact with men, machines and structures.

The cooperative plan obviously does not provide complete executive training, but it does afford an opportunity for intimate work with men and with equipment, the kind of opportunity which the average continuous engineering student cannot easily obtain until after graduation and which he probably will not obtain at all because after graduation the attraction of office work will be too compelling. The cooperative student observes that even the minor executive makes decisions and calculations which cannot possibly be based upon a technological analysis. For example, a twenty ton casting is in work on a large boring machine and the machine's driving train fails. Shall

* Society for the Promotion of Engineering Education, "Report of the Investigation of Engineering Education," Pittsburgh, 1929, Vol. II, p. 1061.

a make-shift repair be made and the operation continued, or shall the casting be removed to permit complete overhauling? How long will it take three men with a locomotive crane and a one yard bucket to unload a carload of coke?

The S.P.E.E. Report of Investigation of Engineering Education declares that "The attributes of the cooperative plan in developing particular personal traits and points of view, together with the orientation to industrial organization which it affords, would seem to indicate that it is particularly advantageous as a means of developing personnel for the administrative and operating side of industry. This, indeed, seems to be the peculiar merit of the system which is indicated most clearly." *

Other Advantages

Individual cooperative institutions and investigators of the cooperative system have announced and explained secondary or "by-product" advantages of the system, including the following:

1. The institution is more closely integrated with the community through the many contacts resulting from employment arrangements with industries.
2. Classroom and laboratory facilities may be much reduced as one-half the cooperative students are at all times away for employment.
3. Although student earnings are altogether incidental in the whole scheme of cooperative education, their income does enable a number of students to obtain an engineering education whose economic status would otherwise prevent their attempting college work.
4. Teachers of engineering and application type courses keep informed concerning current practices and developments. The instructor whose students have just returned from work in engineering offices and in plants cannot teach techniques which the industries have long since discarded.
5. Cooperative students mature early and quickly as a result of their employment contacts and experiences. An important element of maturity is good judgment. Another is stability, a faculty for appraising influences and events and for reacting only to those which are significant.

This enumeration might easily be extended.

After careful consideration, these advantages have not been designated as objectives pertaining essentially to the cooperative plan.

This does not mean that these advantages are doubted or that pursuit of them is not approved. Any institution clearly is free to seek these advantages if the existing circumstances permit. However, these advantages do not seem to bear directly upon the educational process; rather, they are incidental results of the cooperative method. By way of illustration, the establishment of a college or university in a town or city is doubtless of great advantage to its citizens, but the well-being of the citizens is most certainly not an objective of the college or university. Moreover, the number of institutions which have claimed any one or more of these secondary advantages is not sufficient to be considered representative of the group of cooperative colleges.

* *Ibid.*, Vol. I, p. 609.

Administrative and Operating Requirements

The cooperative college must fulfill certain minimum conditions in order to gain the objectives of the system, and to avoid failure or, at the least, serious deficiency of result. These minimum conditions are:

1. Educational and training values must be paramount considerations in the placement of students.

R. S. Tour insists that "The selection and scheduling of jobs on the basis of their educational values has always been a cardinal feature of the cooperative plan. This view of work disposes of two common misconceptions regarding the part time instruction. One is the idea that any kind of work will answer the purpose, since the aim is merely to give the student an initiation into practical affairs. The other is that partial self support for the student is the major purpose, instead of an incidental result, of his employment." *

A student of civil engineering, for instance, must expect to exchange a production job in a forge plant which pays $1.50 per hour for a highway maintenance position which pays only $0.95. Earnings, convenience of location or transportation, working conditions and personal preferences of the student must yield to educational advantages if these advantages cannot otherwise be achieved.

2. Employers and their officials must clearly understand the educational purposes of the plan, and must derive direct and quite obvious advantages from their cooperation in it.

Business and industrial institutions are neither engaged in education nor are they primarily social or altruistic enterprises. They cannot fairly be expected to support and take part in the plan if they have nothing to gain from it. Such gain my be either the recruitment of their own technological forces, or the maintenance of competent engineering personnel in the community in which they are established.

3. There must be no exploitation of the student by the employer.

Cooperative relations with any employer are in danger of collapse as soon as the employer sacrifices the educational purposes of cooperative employment to his immediate employment needs. (On the other hand, the student must meet all employment requirements and should not be in any way privileged nor should he expect to be.)

4. The higher administrative officers of the school or college must be enthusiastic supporters of the plan.

No over-enthusiastic individual or group of the engineering faculty can alone make the system work. The operation of the plan affects not merely the academic departments but the personnel offices, the business offices, the extra-curricular undertakings, the registrar or recorder and even the athletic offices. Hence, only the authority and the influence of the highest officers of the institution will sustain the plan throughout all these divisions and departments.

5. Employment of students must be as closely supervised as their academic work and status.

* "Chemical Engineering under the Cooperative System," American Institute of Chemical Engineers' *Transactions*, Vol. 17, 1925, p. 131.

This involves:

a) Frequent and preferably personal check with each student's employer and, if necessary, with the student's immediate supervisor.
b) Regular conference with the student concerning progress, employment conditions, and character of his duties.
c) Thorough employment reports and records, including name of employer, type of work, caliber of performance, hours completed, wages earned, difficulties encountered and solved and additional significant data.

6. A plan must be made for each student's work in compliance with the broad aims of the cooperative method, his field of study and special vocational aims, and his capacities, interests and personality, in so far as these can be ascertained.

In his biography of Dean Schneider, Professor C. W. Park stresses the point that "if a student's outside work is to be something more than intermittent employment, his experience must be selected and graded in accordance with a central purpose. This principle will be recalled as one of the fundamental tenets of the cooperative system. . . . For example, a general arrangement, which in the policy of the Department of Education applied to all students, was the graduation from subordinate tasks, directly in contact with labor and with the raw materials of production, to positions of responsibility in management, design, accounting or some other phase of industry in which a complicated process is seen as a whole." *

* "Ambassador to Industry," The Bobbs Merrill Company, New York, 1943, p. 196.

Plans almost invariably must be adjusted to circumstances, but this is no excuse for making no plans at all.

7. The college must maintain organized counselling service for cooperative students concerning their employment relations.

This service should be competent, sympathetic, abundant, and convenient.

8. Cooperative students should be carefully selected in the first place with reference to employment qualifications.

It may be difficult to place a student because of physical disability, peculiarity of personality or citizenship status. Cooperative colleges incline to the view that it is improper to deny admission to an otherwise qualified student who may be thus handicapped, but that the student must be tactfully warned in advance. Coordinators can usually find a limited number of openings adapted to the special needs of these students.

9. Adjustment must be made for cycles of industrial booms and depressions.

This is always a major problem in the administration of the cooperative plan. When an appreciable percentage of cooperative students is unemployed, the morale of the group is adversely affected, and academic work is likely to suffer. Adjustment devices and procedures include the following:

a) Effective service of the employer by the cooperative institution. In turn, the employer can be expected to make serious efforts to maintain student employment in dull periods instead of promptly laying students off.

b) Restriction of the number of students in normal and boom periods. There can be no justification for enrollment in peaks of production of so many cooperative students that great numbers of them will be dismissed with the first slight recession in production volume.

c) Placement of as many students as possible in long established and stable types of industry in which fluctuation is less severe, such as food processing, fuel production, power, transportation and communication utilities.

d) Reduction in the employment hours of all students rather than laying off a few completely while the remainder continue fully employed.

e) Spread of employment at all times over as many employers as possible, consistent with efficient supervision by college officials.

f) Inducing employers during dull periods to undertake special, long term development projects in which students can be advantageously engaged.

g) Allowing limited cooperative work credit for diligent and intelligent efforts on the part of the unemployed student to find work on his own initiative.

h) Aggressive search for employment openings by investigating want ads, announcements of new incorporations, publications of contracts let and orders placed, and even by advertising for positions; likewise by close contact with officials of manufacturer's associations, trade associations, engineering societies, chambers of commerce and similar agencies.

Industrial Coordinator

Cooperative employment relations of the school or college and of the students should be placed in the exclusive charge of a single official who is usually called the "coordinator." He reports to the dean, although he exercises a wide discretion in fulfilling his duties and responsibilities. Ordinarily he has the status of a director of department in the college, and, except in small institutions, or in large institutions with few cooperative students, he is given no other duties.

Experience indicates that the industrial coordinator is most likely to succeed if he possesses the following qualifications, in addition to those which are taken for granted in any college official:

1. Engineering education or wide engineering or industrial experience.
2. Sympathetic attitude toward students and young people.
3. Information and experience concerning personnel procedures and techniques.
4. Vocational information in the fields of engineering and industry.
5. Willingness promptly to solve problems as they arise, without regard to personnel convenience, office hours, work routine, etc.
6. Ability to solve problems completely without compromise of principle, indecision, evasion or timidity.
7. Fairness, tact and skill in dealing with students, employers and faculty.
8. Buoyant, optimistic and confident attitude in the face of difficulty and disappointment.
9. More than usual resourcefulness in appraising a complex situ-

ation and in revising plans and procedures accordingly.

10. Ability to adhere to standards and principles under widely changing and complex situations.
11. Large capacity for friendship.

Conclusion

This report has not touched upon one question which is frequently raised by partisans of the cooperative method, and that is, does the student not gain certain educational values by his employment experience whereby the curriculum in the cooperative colleges might be somewhat shortened? Is cooperative employment experience not entitled to at least some academic credit?

The question has not been considered because this is intended to be a statement of what the cooperative colleges now hold, rather than a projection of new policies. In the meantime, the Engineers' Council for Professional Development allows no academic credit for employment experience whatever, and holds the cooperative colleges to the same weight of credit hours in the curricula as the conventional, non-cooperative institutions.

It is likely that this position of the Council does not involve an outright denial of all academic value in cooperative employment. More probably the Council merely recognizes that it is extremely difficult to evaluate employment experience in terms of academic credit. Certainly the cooperative colleges can reasonably contend that many months of carefully supervised employment are the equivalent at least of the familiar college shop courses, where they are still required. On the other hand, the colleges could not possibly demand an hour by hour conversion of shop work into clock hours of lecture or recitation, or even laboratory. Until the cooperative colleges themselves jointly determine and submit to the Council an acceptably norm of comparison, the Council can hardly be expected to alter its existing interpretation.

The Cooperative Education Division of the Society should soon undertake this important task.

The cooperative colleges do not by any means contend that their plan should be adopted by all schools and colleges of engineering. Indeed, no institution should even experiment with the system unless located in an urban or industrial community, or unless abundant opportunity for cooperative employment is otherwise available. One or the other plant or industry is not sufficient for an extensive program. Experience has shown that, unless there are to be radical changes in employment conditions and policy, thousands of employees are required to absorb a few dozen cooperative student employees.

As already stated, this report is not intended to contain any new material. It is designed rather to be an authoritative statement, which the cooperative colleges approve, based upon selections from the mass of pronouncements and claims for the plan by very many responsible and enthusiastic adherents.

Committee on Aims and Ideals of Cooperative Engineering Education

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Research and the Staff Member*

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Research for Regular Staff Members

The subject chosen for this discussion is concerned with research and its relationship to the university and staff members. Research should perform or fulfill a useful function in the university and a careful appraisal of all that it implies must be made.

The university, in an engineering sense, may be compared with any operating and successful manufacturing company. Raw material is received in the form of high school graduates. Some of the raw material is good—capable of being processed according to the established practice of the institution—and some is not so good and must be discarded. The purpose of the process in this case is to teach—to train—the student in a prescribed way so that he may, as a processed product, enter the profession of engineering, earn a good livelihood, and (in the words of a much used definition) realize a successful career in "directing the great sources of materials and power in nature and converting them to the use and convenience of man." My object here is to emphasize that the engineering schools' function is the training and teaching of engineers and that the regular staff members are agents directing their efforts to this end.

Research and the Student

Since one of the purposes of research is the teaching of students, let us discover if this purpose is accomplished. First, a student working in research must learn the research method. Much has been said about the research method and research technique. These, in general, refer to finding facts, interpreting them, applying them in working sequence, and then using them. Engineers who have had training in the research method have created an employment demand. Some research minded organizations fail to employ any but research trained graduate students for their staff work. Others prefer them since surveys made on business leaders have shown that the engineering and scientifically trained men are likely to become leaders of business and management.

Engineering requires continual improvements which are handled best by a research trained man. In a competitive system such as ours the concept of seeking better ways of doing a definite job requires the research method.

Colonel A. W. Lissauer, former president of the Louisville Drying Machinery Company, once said: "There are only two reasons for the existence of a company in our competitive sys-

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tem. A company must be able to produce something better than a competitor—and can then demand a premium for its product—or must be able to produce the same product at less cost—in which case no premium can be demanded." Properly conducted research accomplishes these ends.

A second result lies in the inspirational influences coming from working in research. The thrill of hunting for something unknown, of tracking down various leads, of putting new concepts together, of watching a complete working picture take form and finally realizing that a new process has resulted from the correct piecing together of fundamentals—this thrill can only be felt by those who have carried out the research process.

Other results which are partially developed in the student by research may be enumerated as follows: (1) Resourcefulness, (2) practical judgment, (3) reliability, (4) character improvement, (5) patience, (6) imaginative ability, (7) independent thinking, and (8) initiative.

Thus, research aids in teaching the student along sound and tested lines and helps fulfill the primary function of the university. If research accomplished only this one thing, it would be well worthwhile.

Research and the Staff Member

The benefits of research are not restricted to the student. The stature of the university professor is increased by his research activities; indeed, his publications are frequently a measure of his capacity and ambition. Further, the staff member's research pervades his graduate and undergraduate courses and directly benefits the students.

Any project in research requires first a complete and thorough search of the literature of pertinent subjects. This search enables the staff member directing the research to form as complete a picture as possible on the state of the project and (as in putting a jigsaw puzzle together) enables him to see parts of the whole that are missing. This creates a need. Once a need for new information is created, planned research programs for fundamental data, economic improvements, or invention may result.

The literature search, and the subsequent experimentation which follows, add to the knowledge of the subject and help keep the staff member abreast of the times. The tendency has been for the staff member to work the new found knowledge into his courses and to keep his subject material alive.

The Chemical Engineering Department at Vanderbilt has operated under the policy that a man should excel in some field. With this in mind, our staff members have gone into some field of specialization over and above the requirements of fundamental and general chemical engineering teaching. As an example, Mr. Tiller, as I suggested when he first came into the department, has specialized in the field of drying. He *had* been one of the first workers in the infra-red field and had published one of the first theoretical papers on the subject. He, only to mention a few of the values gained by this specialization, has been consulted internationally in this field, has published basic information in foreign journals, has acted as expert witness in a patent case, has been sought out by various firms for drying studies (Vanderbilt has two research fellows and one undergraduate project in drying), and has worked new and interesting information into his lectures.

It is safe to say that this policy has

added to the prestige of our institution. A university can train the best chemical engineers possible but, *if* in some way this information does not become circulated, part of the value is lost. Research specialization (not overdone) reacts to the university's advantage.

It is true that a man who becomes outstanding in a specialty can demand a higher salary. He is sought by industrial leaders and in time will probably be offered such an inducement that he might be lost to the institution. This fact is not as serious as it might at first seem. We have found that, with specialization, a man's consulting capacity and value increase to such a point that he might be earning as much consulting as he does from his teaching. Many of my friends have found this to be the case. Thus, consulting retainers and small bits of remuneration coming from directing fellowships so supplement the salary of the staff member that the lure of industry diminishes in relation to teaching. This is another value which research offers regular staff members.

As a side thought in this respect, there may be a tendency in some universities to eliminate any remuneration from research except that paid directly as salary. This is undesirable for two reasons: *First,* it cuts the salary of an outstanding man down to a level where industry may induce him to leave for applied research. (Actually, one of the primary needs of universities is to increase salaries.) The student then loses his contact with the exceptional men. *Second,* it removes some of the incentive for seeking out new projects and new applications. Those members of a university staff who are either too lazy to develop a specialty, or are envious of the obvious success of others, are the first to advocate the elimination of additional remuneration for research and the curtailment of consulting activities of staff members.

A further advantage of research to the staff member comes about in his industrial contacts which are of particular value to engineering teachers.

Industrial and Fundamental Research

Engineering and industrial research are usually of an applied nature in contrast to other research of a more fundamental and theoretical type. During the resent era, industrial research has been found to be a necessary adjunct to a modern, competing, and progressive business.

The National Research Council and the National Resources Planning Board have released figures indicating the following: The American industry employs research workers approaching the 100,000 mark in about 2,500 laboratories at an expenditure of about $4,300.00 per worker. About 22 per cent of these are trained engineers and about 15 per cent of our engineering graduates would have been placed in industrial research if the war had not interfered. The rate of increase of men employed in research has been about 10 per cent per year and during the last depression the companies maintained their research staffs. Research helped reduce operating expenses, developed new products, and enlarged the uses of old products.

Many of our separately operating research foundations and institutes have been attempting to sell the universities a "bill of goods." They would like the universities to sponsor pure, theoretical, fundamental research and let *them* make the profitable application. I, for one, am not in favor of this procedure. It is my belief that if a staff member develops fundamental research he

should be encouraged to develop as many applications as possible. His students, the product of his efforts, go into industry and make definite contributions. Why should not the staff member acting in a consulting capacity help carry his researches through the pilot plant scale and at the same time learn more of the requirements of industry so that he may pass them back to his students? I believe he should.

(As a side point) since engineering or scientific research and industrial application go hand in hand, it is logical for scientific schools to develop divisions of industrial research in which both parties can reap the many mutual advantages obtained by their close cooperation.

The University of Louisville has adopted such an institute as have the University of Chattanooga, Lawrence College, Illinois Tech, Louisiana State, and others. I believe that universities should drive to establish industrial research linkages and not allow (through their inactivity) the endowed research foundations to gather in the cream of research projects. The university can offer trained men for industry, less expensive operating costs, and the advantage of the combined ideas of their staff members as a real competition for foundations merely offering research.

A direct advantage of research to the university, and, indirectly, to the staff member, accrues through the acquirement of facilities which serve both the research project and the teaching laboratory. Any industrial fellowship allows definite sums for purchase of equipment, supplies, etc. I have found that industry wants results. Saving in time is valued more than the expense of needed equipment. (Some of labor's pressure on management can be seen in parallel reasoning.)

Thus, to summarize:

The student gains by the viewpoint, training, course material, industrial contact, and equipment obtained through research.

The faculty member gains by better teaching, keeping abreast of the new developments in his field, by a higher standard of living, by industrial contact, and by equipment.

The university gains by producing better trained graduates, by having stronger departments, by holding better men, by stimulation of its faculty, by the unsolicited advertising value of the researches, by holding close relationship with industry, and by the extension of their facilities.

And industry gains by obtaining better trained men, by their close contact with the faculty member, by obtaining worked out processes for commercialization and by having a wealth of knowledge available for their asking when various problems arise.

Rightly, this discussion should end here, but there are other matters which should be brought to your attention.

In the past, research largely has been carried out in colleges as a side line. Sometimes, no cognizance is made of research activities and no credit is given or allowed unless the research is a scheduled course. The work is considered extra-curricula. Yet the man engaged in research is generally of the most productive type and needs the utmost encouragement that can be given him.

Frequently men of high caliber are burdened throughout their early productive years with routine work and elementary courses to the point that intellectual development is hampered. Research is discouraged. Yet it is absolutely essential for an institution which expects to become a great uni-

versity to recognize and nurture to the fullest extent the latent abilities in its young men. The administration should never allow an instructor to despair of goals to be attained. If advancement in rank is slow, a certain measure of compensation can be realized by encouraging intellectual development, and publication of research and text-books. To become or remain great, superior judgment must be exercised in dealing with the men who form the foundation for the future.

In our department I am trying to adjust schedules to obtain the most productive load. Twenty to twenty-five contact hours leaves nothing for a productive research load. A twelve to fifteen hour load is productive and the department under such a condition can expect valuable developments both in research and teaching. In fact, one publication from our department has developed into an additional project which brought a $3,000.00 piece of equipment. This equipment is used both for laboratory teaching and research.

It is, in my opinion, an obligation of the university to place research in its proper place, to carefully examine research appropriations, and to recognize the work as well as the advantages. The faculty member should be encouraged to advance the research program by most productive loads, proper environment, and by a salary scale commensurate with the times.

Before closing, let me commend the TVA on their research attitude and their cooperation with engineering schools. This shows a broadmindedness which could well penetrate all our governmental agencies. They will gain in the use of all the school facilities (staff and physical) and the schools will gain in reciprocal fashion.

It is realized by everyone who has studied World War II that the war was a technological war and that victory was assured by research advancements coupled with large production. The research man is as much a national resource as coal or iron.

Dr. Lee Irvin Smith, in discussing problems in postwar education, has stated that:

"The results of *research* in science and technology shape the welfare of our country and people to an ever-widening extent. To keep pace with this trend and derive the most good from our natural resources and brainpower we should construct an educational system which will be more efficient in raising the general level of education, and which will seek out and train the really gifted young people to a point where the application of their training and abilities will produce the maximum of happiness and security for all. An educational program toward this end would mean the redesign of courses beginning with the elementary school and continuing through the university."

Research is an undisputed need in this program.

Production Illustration *

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Production Illustration is a device or method for speeding the production of mechanical assemblies. These illustrations breakdown and depict in simple, easily understood drawings the operations necessary to manufacture and assemble each component part of any assembly. The average worker, after a few moments study of this drawing, understands precisely what the results of his work will look like and how to achieve the results.

As an introduction to the subject, it would be well first to give its historical background and its reincarnation due to war's necessity, before going on to its present use in industry, its future possibilities, and its suggested inclusion in all Mechanical Engineering Training.

Historical Background

The earliest known uses of the sketch for explanatory purposes were the drawings of the early cave dwellers. They, having no written language, were forced to use the only method possible to record their thoughts and actions. This enables us to get a valuable insight into their life and activities which, otherwise, would have been unknown to posterity.

The Egyptians and the American Indians used the pictorial, descriptive method of recording their history. The early Chinese, with their usual perspicacity, understood the power of the sketch. Confucius hit the nail on the head when he said, "A picture is worth 10,000 words."

Leonardo DaVinci, the famous Italian scientist, inventor, artist and sculptor, knew the value of the perspective sketch. He used it almost exclusively for depicting and explaining his ideas and inventions. Born in 1452, he was already famous when Columbus discovered America. An excerpt from the Encyclopedia Britannica says "History tells of no man gifted in the same degree as Leonardo was at once for art and science. In art, he was an inheritor and perfector, born in a day of great and many-sided endeavours on which he put the crown, surpassing both predecessors and contemporaries. In science, on the other hand, he was a pioneer, working wholly for the future, and in great part alone. That the two stupendous gifts should in some degree neutralize each other was inevitable."

The pictorial definition of mechanical problems is as old as history.

The outstanding profession in which artistic rendering has consistently been used is architecture. It has always been necessary to have a picture of the finished structure. For example, in city planning the blending of architectural styles with the existing surround-

* Presented to the Pacific Southwest Section, S.P.E.E., University of California, Berkeley, February 22, 1946.

ings is necessary. Other reasons too numerous to mention here require that a completed conception of the entire plan be reduced to black and white, or to color, on the drawing board.

War Experience

The title "Production Illustration" was coined in 1939 at the "Douglas Aircraft Company," for the purpose of naming a newly formed Department, created for the sole purpose of illustrating work to be accomplished on the production lines by people having no knowledge of blueprint reading, and very limited mechanical knowledge. The aircraft industry, rapidly expanding at that time in a frantic effort to supply the British and French Air Forces with the necessary aircraft, had the vital and immediate problem of training the greatest number of workers in the shortest possible time. It was impossible to train all these people, coming from all walks of life, to be mechanics or even to read blueprints intelligently in the time available.

Therefore, a group of specialized engineer-artists known as production illustrators had to be created for the purpose of illustrating the work to be done by each person in every position on the line. These illustrations were known as "illustrated Job Tickets" and gave each worker a clear picture of the local structure as he would see it on the airplane, showing where the subassemblies and parts should be attached in accordance with a numerical operation sequence. A list of the necessary bolts, nuts, screws, clips, etc., to attach these parts, and a list of the tools necessary to do the job were included on the drawing.

A complete series of "illustrated Job Tickets" was based on an elapsed time schedule for the complete assembly line. Competent development men, working in conjunction with the tooling department and the production illustrators, established a definite working time element for the assembly line as a whole. The value of establishing the time standard or base is at once apparent.

Of course, blueprints could not be eliminated in any department where precision parts were to be manufactured, nor could these illustrations ever take the place of the engineering drawings. The "Production Illustration Group" read and analyzed the blue prints for the purpose of explaining, by means of perspective sketches, these engineering drawings for the benefit of the people who could not read them for themselves. Thus, the possibility of mistakes was minimized, thereby saving the time of valuable supervisors and leadmen who would otherwise have found it necessary to explain the job to each worker many times over. The system also afforded some guarantee that the job would be done in the best and quickest manner, since the procedures were originated by experienced mechanics, each of whom was a specialist in his line.

The preliminary design department of the *Douglas Company* had received great encouragement in pictorial representation for Army and Navy bids from *Mr. A. E. Raymond* and *Mr. E. F. Burton,* who were at the time Chief Engineer and Chief Designer, respectively. In August, 1939, a complete picturization of the proposed manufacturing breakdown and its progressive, detailed fabrication, plus a position breakdown plan, on a mechanically moving assembly line, was for the first time included in a military airplane bid. It received very favorable comment from Washington and proved a boon to the Production Design and Tooling

FIG. 1

Departments. In anticipation of the imminent rush of orders for national defense and aid to Britain, with the resultant expansion, mechanically moving lines, and lack of trained personnel, the Production Illustration Department had been organized and assigned the duty of studying and breaking down into manufacturing production units the DB-7 type twin-engined attack bombers. The results of this work were to be used by engineering, tooling, and shop personnel. At that time the fuselage was being fabricated as a complete unit and difficulty was being experienced with installation on the final assembly line due to the very restricted working space in such a small fuselage.

Perspective sketches were made showing suggested remedies for this condition. After several conferences between the engineering and tool design groups, we decided that the fuselage be split vertically on the center line and fabricated as right and left halves. See Fig. 1, *Production Breakdown Diagram.* This allowed more men to work on fuselage fabrication with greater freedom of movement. The same advantage also applied to the assembly line where the two halves received their respective installations. Nearly 80 per cent of the internal equipment and functional installations could be installed before the two halves of the fuselage reached their joining positions on the assembly line.

It was now necessary for the manufacturing division to estimate how many installation positions would be required on the final assembly line due to this change, in order to produce the required output of parts and assemblies. A development group was organized consisting of the Supervisor and his assistant for that model, plus several leadmen who were specialists in their particular line. It was their responsibility to breakdown the information given on engineering blueprints to determine the installations for each assembly line position, to approximate the amount of work to be done in each position on an elapsed time basis, and to make suggestions for the necessary drill jigs, templates, special tools, etc.

From their findings an organized line was established, and the necessary floor space, storage facilities and handling fixtures were determined. At the same time, the production illustration group was busy coordinating this information

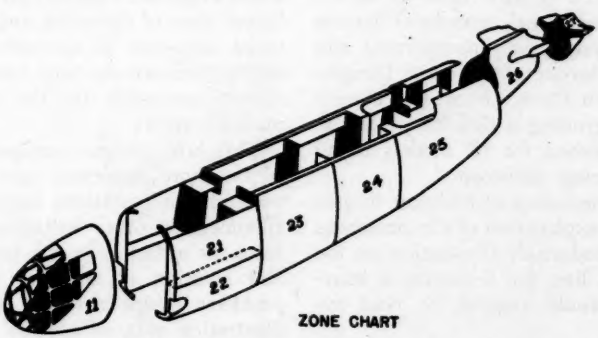

FIG. 2

by means of sketches, thereby promoting more rapid decisions through correct and simultaneous visualization of the general problems.

The fuselage halves on the assembly line were divided into *working zones* for the purpose of illustrating in detail the work to be done in these zones (Fig. 2) at every position on the assembly line and for this purpose the development men supplied all the necessary information for inclusion on each zone position illustration, as follows:

(*A*) All part numbers and a description of their installation.
(*B*) All component attaching parts, such as bolts, nuts, washers, cotters, etc.
(*C*) All jigs, templates, and special tools used.
(*D*) Approximate estimated time based on previous experience.
(*E*) A list of company and personal tools required to do the job.

This information was coordinated and checked with the planning department to provide for the routing of parts and subassemblies to their proper position on the assembly line.

These trial production illustrations proved to be of such value as an organizing and visual procedure function that the system was incorporated into the basic layout of the new Douglas Long Beach Plant. From this experimental beginning a definite procedure was established for all models in all manufacturing divisions.

It is unnecessary at this time to give a detailed explanation of the numerous uses of Production Illustration on the production line, but if anyone is interested, I would suggest he read my book.

Before going further, however, I would like to refer again to the "Illustrated Job Ticket" as issued to all workers on the production line, and show you how completely and in what detail were the instructions illustrated and organized. For an example, refer to Fig. 3, it was picked at random and represents the final installation of the nose wheel, it being a *two-hour* elapsed-time Job Ticket. First refer to the job number 1812–22: the first two figures (18) give the worker the position of the fuselage on the production line; the second two figures (12) give the code numbers for hydraulic unit assembly, and the last two numbers (22) indicates the fuselage zone. If you refer to Fig. 2, you will notice that zone (22) is in the forward part of the fuselage directly under the pilot's compartment. On the right hand side of the Job Ticket is a list giving the tools and parts necessary to do the job. (These tools and parts together with the Job Ticket are issued from the stock room adjacent to the designated position on the production line.) Under this list of tools and parts is a listing of each operation in numerical sequence with corresponding numbers on the sketch. For example, it will also be observed that operation No. 1 is subdivided into two sub-operations A and B, giving an enlarged view of the parts, and their pictorial sequence of assembly. If the instructions are carefully followed it is almost impossible for the worker to make an error.

This brief outline summarizes some of the more important uses to which production illustrations have been put. Innumerable other instances of their value as a factor in the coordination and solution of complex production problems could be cited. Production illustration was enlisted to serve the cause of democracy at war, and is now

Job Ticket No. 1812–22 *Model A–208*

Tool Requirements

½" Drive Ratchet
½" Drive 1" Socket
½" Drive ½" Socket
½" Drive Ratchet
1 Large Screwdriver
1 Pair Diagonals
1 Pair Pliers
1 Brass Bar 10" Long
1 12 oz. Ball Peen Hammer

Procedure

Oper. No.			
1. Install	Strut Assembly		
	Apply a Thin Coat of Parker Thread Lube to Pin (A) Before Installing. Install as Shown in Detail "A".		
	(A) 1098970	Pin	2 Req.
	1098967	Washer	2 Req.
	AN380–4–4	Cotter	2 Req.
	AN320–10	Nut	2 Req.
	(B) AC386–4+13	Taper Pin	2 Req.
	AN380–2–2	Cotter	2 Req.
	AN975–5	Washer	2 Req.
	AN320–5	Nut	2 Req.
2. Install	Mechanism Assembly		
	Use Same Procedure as in Step No. 1.		
	(C) 1098965	Pin	2 Req.
3. Connect Mechanism Assembly to Strut Assembly			
	AN20–36	Bolt	1 Req.
	S-102661489–108	Spacer	1 Req.
	AN320–9	Nut	1 Req.
	AN960–916	Washer	1 Req.
	AN380–4–4	Cotter	1 Req.
4. Install	Cylinder Assembly		
	(E) AN6–15	Bolt	1 Req.
	S105960–8–375–624–749	Spacer	1 Req.
	AN310–6	Nut	1 Req.
	AN960–616	Washer	1 Req.
	AN380–3–3	Cotter	1 Req.
	(F) AN6–14	Bolt	1 Req.
	S105960–8–375–624–749	Spacer	1 Req.
	AN310–6	Nut	1 Req.
	AN960–616	Washer	1 Req.
	AN380–3–3	Cotter	1 Req.
5. Connect Hose No. 4098400–21 and –18 to Cylinder			
6. Tighten and Safety All Nuts and Bolts			

FIG. 3

being used extensively to increase production for peace.

War Training of Illustrators

The question in your minds as professional educators is where and how is it possible to obtain enough trained illustrators. The answer is there were very few indeed; therefore a training course was instituted at the Douglas Aircraft Company by the author under the able sponsorship of Mr. C. T. Reid, first as a company activity, and later (due to urgent pleas for illustrators by other companies) as a government sponsored War Training course within the E.S.M.W.T.

The first of these training programs, designed to help only engineers, was inaugurated at the California Institute of Technology under the supervision of the author, and was primarily a course in technical sketching. In September, 1941, instruction in production illustration was inaugurated at the Art Center School in Los Angeles under the tutelage of Mr. O. J. Chayie, Assistant Supervisor of Production Illustration at Douglas, and continued until May, 1942, when the complete program was absorbed by the California Institute of Technology under the author's supervision. At a later date similar courses were established at the Universities of California and Southern California, both in Los Angeles.

One frequent misapprehension that must be corrected is the idea that although production illustrations are simple in themselves, the process of training illustrators skilled in this work must necessarily be long and complicated—all of which is incorrect, as abundant experience has sufficiently proved. In the Government-maintained schools in the United States the time normally required for a student to complete the standard course of study hereinafter outlined was scheduled as follows:

Day Students—Eight hours per day, five days per week. Six weeks' study of Perspective and Freehand Sketching. Six weeks' study of Production Illustration, Catalogue, and Handbook Illustration. Total class work, 480 hours.

Evening Students—Three hours per evening, three evenings per week. Eight weeks' study of Perspective. Twelve weeks' study of Production Illustration and Catalogue Illustration. Total class work, 180 hours.

The greater time required by the day classes was due to the fact that those students were usually persons of little special training, whereas those in the night classes were likely to be persons already employed in industry, with somewhat greater aptitude for illustration and, usually, some drafting or sketching experience.

The graduates from these classes in nearly all cases were immediately absorbed in this new line of work. In fact, the demand continuously far exceeded the supply. The records of the California Institute of Technology and the Art Center School Extension at Los Angeles show that 87½ per cent of all students given the "Certificate of Satisfactory Completion" of the course of study reported themselves as employed in the work. Others were doubtless so employed in other parts of the country.

One of the basic requirements of a good training program for production illustration lies in the choice of instructors. Since production illustration is mainly for shop use, it is necessary to keep the illustrations simple to read as well as to draw. The every day shop problems must be understood

by the illustrator or he will not be qualified to work out satisfactory solutions.

The ideal trainee for a first-grade production illustrator would obviously be a graduate mechanical engineer having experience in the design and manufacture of mechanical products, plus ability to express his ideas in freehand perspective sketches. It was very evident that this type of student material was least likely to be available in adequate numbers; therefore, it became necessary to accept intelligent candidates with less or no engineering training, direct the instruction of the best of them toward producing Production Illustration supervisors, and the remainder for such phases of the work as their individual abilities appeared to warrant.

The entire program of training was developed around the idea of teaching the prospective illustrator the most simple and direct methods of developing and drawing the individual major components of the structure to be illustrated, and then to assemble those components in proper relationship to constitute the complete structure shown in perspective. While the method used concerned the development of the contours of an airplane largely through means developed in the study of circles and ellipses in perspective, full advantage was taken in practical work of all proved short cuts—provided only that they maintained scale accuracy as well as time saving. For example, the "perspective co-ordinates" method of establishing perspective points by means of quick calculations based upon simple empirical formulae was developed by members of the Production Ilustration Department of one of the divisions of the Douglas Aircraft Company.

Another development, also worked out in a Douglas division, was the three-point perspective drawing board, by means of which perspective drawings were made in a quick and simple manner.

If anyone is interested in a detailed description of the instructions given to the students in these courses, I again refer you to my book.

The Future

(Quote from John Treacy's "Production Illustration," published by John Wiley & Sons, Inc.)

"The future of Production Illustration in industry as a whole is limited only by the imagination and energy of its proponents, and the question of its universal acceptance by the recognized centers of Engineering Education. There are thousands of new applications in manufacturing, engineering, building, construction, and numerous other fields. Wherever technical information is transmitted by an engineer or designer to a builder or mechanic, there is an opportunity to utilize production illustration as a medium of exchange. The result will be a more rapid and clearer transmission of data, with the possibility of misinterpretation reduced to the minimum.

"Perspective drawings have always been used where information is conveyed to the layman. For years we have examined and accepted without comment the sketches in the popular magazines of science and mechanics. Too commonplace for special notice have been the illustrated books and articles showing the amateur how to build everything from household gadgets to sea-going yachts.

"In spite of all these familiar examples it took us a long time to apply this logic to industrial production. The aircraft mechanic built his model clipper ship at home with a complete set of illustrations, but he spent untold hours in the factory trying to decipher the blueprints of a four-engine bomber. Now that the four-engine bomber is fully ex-

plained in pictures, it is time to apply these same methods wherever else they may serve.

"The perspective illustration should appeal to anyone who wants to transmit his ideas exactly as they appear to him. Let the architect or the engineer analyze his own problems and ask himself whether or not an illustration will better convey the details of his designs. If his mind is open the answer will very frequently be an affirmative.

"Under the impetus of war, training methods have undergone a far-reaching transformation, one of the most significant being the emphasis on visual education. In motion pictures, slide films, and pictorial drawings subjects of unlimited variety have been taught in a fraction of the time formerly required. The superiority of visual presentation is now established beyond question and its continued utilization is assured. As a proved and highly developed expression of visual training, production illustration likewise assumes a justified position of permanent value."

Illustration and Engineering Education

The author has found throughout his 35 years of design experience, both marine and aeronautical, that the ability to sketch was a very distinct advantage, for quickly explaining his ideas to both his supervisors and his associates, and has been an ardent advocate of perspective and freehand sketching as a must in every engineer's education. I would suggest a course similar to but not so involved as that given in the architectural engineering curriculum. One of the simplest and most comprehensive books on the subject yet to come to the author's attention is "Perspective" by Professor Arthur Bridgman Clark of Stanford University, published by the Stanford University Press.

Before closing I wish to quote Mr. Colin Carmichael, Associate Editor of *Machine Design,* in his report on "The Future of Mechanical Engineering Education" in the S.P.E.E. Journal, Vol. 36, September 1945:

"The usual complaint that the majority of college graduates lack sufficient experience in drafting and in lettering is heard again. Those in industry feel that this should not be a major part of their on-the-job training. As a result of war experiences, it is felt that further developments will take place in the field of drawing that relates to the perspective and isometric illustrations that have become so popular in aircraft production—'Production Illustration.' In the teaching of elementary design and drafting it is suggested that more use of clay models might be advantageous."

I do, however, disagree with his use of clay models in teaching elementary design and drafting, because if perspective and free hand sketching were introduced as part of a student's training, it would eliminate the necessity of fooling with clay, as the student would have a much faster method of visualizing the solid outline of his finished design.

The Hidden Half of the Problem

By C. DONALD CROSNO

Professor of Engineering, New Mexico School of Mines

Why is it that in many engineering colleges the students are taught to only half solve problems? The graduate of such a school is then a slave to handbook engineering. He is utterly lost on any problem a little different from those covered in the handbook.

There are two parts in the answer to a problem—one is the numerical value, and the other is the proper units. Why do we allow units to be neglected?

A student taught the proper use of units has a powerful weapon in any problem. Teach him to carry the units throughout the solution of the problem, and he will have a guard against many common errors; the units provide an automatic check on the logical steps through the problem.

Many leading schools require the units to be included in *every* written equation. In other schools the units are added as an afterthought. The inclusion of units in every equation has many advantages; among these are:

(1) The proper units automatically appear in the answer.
(2) Errors in substitution and in equations used are promptly exposed.
(3) Conversion factors are announced as they are needed.
(4) The significance of some otherwise meaningless equation is often revealed by the inclusion of units.

The proper use of units is quickly learned by the average student. The procedure is to substitute in the equation the units along with each known numerical value. Units for the unknown quantity are not put into the equation, but they will appear in the answer for it. Throughout the solution of the problem the units are treated as algebraic quantities.

Why is this powerful, direct, and wholly scientific method so often neglected? The answer to this question lies in the confusion for the students that has resulted from the various subterfuges that have been used to deal with the equation $F = Ma$.

Why do we not admit that we use the word "pound" to refer to a mass, and an entirely different "pound" to refer to a force?

To avoid this confession, various text-book authors have subjected us to several artificial mechanisms. One practice would have us speak of force only in poundals, and then at the end of the problem, by a multiplication (or is it a division?) convert back to pounds of force. A second practice, and one that works well enough in many cases, is to shun the word "mass" as something evil, and to quickly substitute the value W/g for the offending word whenever it appears. Still another practice grudg-

ingly admits that there is such a thing as mass, but requires the bewildered student to use unwieldy slugs. (How many slugs of butter were you able to buy last month?)

The result of these practices is that the average student *never* learns whether he is supposed to multiply by 32.2 or to divide by it. Why not use terms which are familiar to the student, and, more important, the terms he will continually meet in his engineering work?

There is a direct approach to this problem. The only sound method is to admit that there are pounds of mass and that there are pounds of force, and that they are entirely different. Their relation is that the earth pulls on one pound of mass with a force which is one pound of force. This relationship is given in the equation:

$$1 \text{ lbf} = \frac{32.2 \text{ lbm ft}}{\text{sec}^2}$$

where *lbf* denotes *pound of force*, and *lbm* is *pound of mass*.

With a little coaching the average student distinguishes easily the difference between mass and force in an equation. If the equation calls for a mass, he uses *lbm*; if a force is required, he substitutes *lbf*. It is as simple as that.

Let us see how this works. Here are a few examples taken from the various fields of engineering:

Example (*1*). A 300 lb. weight is suspended by a rope over a frictionless pulley. The other end of the rope is attached to a 200 lb. block which rests on a horizontal plane. The coefficient of friction between block and plane is 0.2. Find the acceleration of the bodies.

Solution.. The force causing the motion is the earth's pull on the 300 lb. block. This is clearly a force and is 300 lbf. The forces opposing the acceleration are Ma (for 200 lb. block), the Ma (for 300 lb. block), and the friction force which is 200(0.2)lbf, or 40 lbf.

We equate the two opposing forces:

$$300 \text{ lbf} = (300 \text{ lbm})(a) + (200 \text{ lbm})(a) + 40 \text{ lbf}.$$

Solving for a gives:

$$a = \frac{300 \text{ lbf} - 40 \text{ lbf}}{300 \text{ lbm} + 200 \text{ lbm}} = \frac{260 \text{ lbf}}{500 \text{ lbm}}.$$

But $1 \text{ lbf} = \frac{32.2 \text{ lbm ft}}{\text{sec}^2}$. Substituting in the equation above for *lbf* gives:

$$a = \frac{(260)(32.2 \cancel{\text{lbm}})(\text{ft})}{(500 \cancel{\text{lbm}})(\text{sec}^2)} = 16.75 \frac{\text{ft}}{\text{sec}^2} \text{ (answer).}$$

Thus the student doesn't have to wonder whether to divide or to multiply by 32.2. The proper units automatically appear in the answer.

Example (*2*). Determine the kinetic energy of a 3,000 lb. car moving at the rate of 30 ft./sec.

Solution.

$$\text{K.E.} = \frac{(M)(v^2)}{2} = \frac{(3000 \text{ lbm})(30 \text{ ft})^2}{(2)(\text{sec})^2}.$$

Here use *lbm* because mass was required in the equation. Since the units in the answer are not those usually required in the measurement of kinetic energy,

we will solve our fundamental equation for *lbm* and substitute in the above.

$$\text{lbf} = \frac{32.2 \text{ lbm ft}}{\text{sec}^2}.$$

$$\text{Hence} \quad \text{lbm} = \frac{(\text{lbf})(\text{sec}^2)}{32.2 \text{ ft}}$$

$$\text{K.E.} = \frac{(3000)(\text{lbf})(\cancel{\text{sec}^2})(900)(\cancel{\text{ft}^2})}{(32.2)(\cancel{\text{ft}})(2)(\cancel{\text{sec}^2})}$$

K.E. = 41,900 ft lbf (answer).

When a distinction is made between pounds of force and pounds of mass, many constants have more meaning than before. For example, the gas constant, R, for air is usually given as $53.34 \frac{\text{ft lb}}{\text{lb °F}}$. When we write it $53.34 \frac{\text{ft lbf}}{\text{lbm °F}}$, its meaning is clarified.

Example (3). Find the work required to adiabatically compress 3 lbs. of air from a temperature of 20°F. to 100°F.

Solution

$$\text{Work} = \frac{P_2V_2 - P_1V_1}{k-1}$$

$PV = MRT$, hence

$$\text{Work} = \frac{MR(T_2 - T_1)}{k-1}$$

$$= \frac{(3\cancel{\text{lbm}})(53.34 \text{ ft lbf})(80\cancel{°\text{F}})}{(1.4-1)(\cancel{\text{lbm}})(\cancel{°\text{F}})}$$

Work = 32,000 ft lbf (answer).

The necessity of conversion factors is often omitted in equations. The method of including units in all equations makes it impossible to omit required conversion factors, as illustrated below.

Example (4). Determine the power developed by a 6 cylinder, 2.0" ×3.5" engine running at 1,800 R.P.M. if the average pressure developed in each power stroke is 80 lbs./in.².

Solution. In handbooks are found both of the following equations for power: Power = $PLAN$ and Power = $PLAN/33{,}000$. Here units must be used to avoid error.

$$\text{Power} = \left(\frac{80 \text{ lbf}}{\cancel{\text{in}^2}}\right)(3.5 \text{ in}) \times (3.14(1)^2\cancel{(\text{in})^2}) \times \left(\frac{1800 \cancel{\text{rev}}}{\text{min}}\right)\left(\frac{3 \text{ strokes}}{\cancel{\text{rev}}}\right)$$

$$\text{Power} = \frac{(80)(3.5)(3.14)(1800)(3) \text{ lbf in}}{\text{min}}.$$

(Strokes, like angles, have no units and can be dropped.) Here the units appearing in the answer clearly call for conversion factors. Since 1 ft = 12 in, we can write

$$1 = \frac{\text{ft}}{12 \text{ in}}.$$

And, since 1 $\text{hp} = \frac{33{,}000 \text{ ft lbf}}{\text{min}}$, we write $1 = \frac{\text{hp min}}{33{,}000 \text{ ft lbf}}$.

When we multiply our equation by these two values, each of which is equal to unity, we find:

$$\text{Power} = \left(\frac{(80)(3.5)(3.14)(1800)(3)\cancel{\text{lbf in}}}{\cancel{\text{min}}}\right) \times \left(\frac{\cancel{\text{ft}}}{12 \cancel{\text{in}}}\right)\left(\frac{\text{hp}\cancel{\text{ min}}}{33{,}000 \cancel{\text{ft lbf}}}\right)$$

Power = 12.0 hp (answer).

Let us consider the equation from physics for the velocity of a wave on

a wire, namely:

$$v=\sqrt{\frac{F}{m}}.$$

Here F is the tension in the wire and m is its mass per unit length. How many of your students would know by looking at that equation that it will be necessary to include the acceleration of gravity; if you tell them, how many would know where to put it? The proper use of units would both call the necessity to the student's attention and show him where to write the factor. Note the following example:

Example (5). Find the velocity of a traveling wave on a wire if the tension is 20 lbs. and the mass is 0.2 lb. per ft.

Solution. The student has little trouble recognizing that tension is a force. m is defined as *mass* per unit length. He writes:

$$v=\sqrt{\frac{20\ \text{lbf}}{\frac{.2\ \text{lbm}}{\text{ft}}}}=\sqrt{\frac{20\ \text{lbf ft}}{.2\ \text{lbm}}}.$$

Obviously the student will have to rid the equation of *lbf* and *lbm*. He substitutes for *lbf* its original defined value.

$$v=\sqrt{\frac{(20)(32.2\ \cancel{\text{lbm}}\ \text{ft})(\text{ft})}{.2\ \cancel{\text{lbm}}\ \text{sec}^2}}$$

$$=\sqrt{3220\frac{\text{ft}^2}{\text{sec}^2}}$$

$$v=56.75\ \frac{\text{ft}}{\text{sec}}\ \text{(answer)}.$$

The inclusion of units in all equations and the use of *lbf* and *lbm* are positive, direct, and logical. Confusion and uncertainty are avoided. All engineering schools will find this method sound and helpful to the student and the practicing engineer. Any engineering department in a school which decides to use this method should certainly insist that it be used in the teaching of physics, for it is here that the student is introduced to that all important equation, $F=Ma$.

While on the subject of units, let us direct our attention to hydraulics where recently some lack of uniformity is noted. Pressure is defined as force divided by the area over which it is distributed. Some authors have been referring to pressure as *unit pressure*, and then misuse the word "pressure" by denoting the *force* on a submerged surface as the *total pressure* on it. Such misuse of an accepted technical term can only result in confusion and vague thinking for the student.

Again, some authors have defined the pressure due to a hydrostatic head as being the product of the depth and the density of the liquid. Density is defined as *mass* per unit volume. Hence the above definition for hydrostatic head gives the wrong units for pressure. The correct equation to use for hydrostatic head is that it is the product of the depth and the *specific weight* of the liquid, where specific weight is defined as the *force* with which the earth attracts a unit volume of the liquid.

Technological Education in a Democracy

By WM. L. DE BAUFRE

Chairman, Department of Engineering Mechanics, University of Nebraska

In 1940 and again in 1944, committees of the Society for the Promotion of Engineering Education "advocated the strengthening of engineering education by concentration on basic elements in the undergraduate years, organization of the curriculum in parallel integrated sequences of scientific-technological and humanistic-social subjects, and by transfer of some of the more specialized subjects to the post-graduate period." These proposed changes in engineering curricula were advocated to meet recognized trends in engineering practice. "One of these trends is the increase in the application of the engineering method in the management and operation of industry as evidenced by the phenomenal increase in the use of engineering graduates in these fields of activity. A second evident trend is the greatly increased need for engineers prepared to practice at high scientific and creative level."

The above quotations are taken from the "Report of Committee on Engineering Education after the War" in the JOURNAL OF ENGINEERING EDUCATION for May, 1944. This report goes on to deplore "the lack in this country of an adequate system of technological educational programs of intermediate or sub-professional type" such as exist in Great Britain, Germany and Russia.

Three levels of technological education are thus recognized, two of which are to be reserved for colleges of engineering while the third is to be delegated to technical institutes. But until a large number of technical institutes are established in this country, engineering colleges will continue to function at all three levels. And it may be questioned whether the establishment of a large number of technical institutes would be as well suited to our democratic way of life as to the class distinctions in European countries where the great majority of young people are barred from colleges and universities.

In the United States, a considerable group of educational institutions have been founded from time to time to provide technological training at the sub-professional level; but such institutions have nearly always levitated to the four-year engineering program. Among this group may be mentioned the Polytechnic Institute of Brooklyn, Cooper Union in New York City, Drexel Institute in Philadelphia, the Carnegie Technical Schools in Pittsburgh, Armour Institute in Chicago.

Also, two-year terminal programs have been set up in schools with four-year engineering curricula; but such two-year programs have attracted few students. At the University of Nebraska, for example, a two-year terminal program was set up in the twenties in the Mechanical Engineering Department, but only one student was registered in this two-year program in the

several years of its existence. In 1941, five two-year terminal programs were set up in the Junior Division of the University of Nebraska by the College of Engineering. Only four students have been registered to date in these programs. Such two-year terminal programs are undoubtedly regarded as inferior to four-year engineering curricula and students have selected the latter even when they could remain only two years in college.

Such technical institutes as exist in the United States do not consider their training inferior to that of engineering colleges. Mr. Faig of the Ohio Mechanics Institute in Cincinnati pointed out to the Society for the Promotion of Engineering Education that James Watt and Michael Faraday were not college graduates. He claimed that graduates of his institute can reach the highest positions that industry has to offer—and some undoubtedly have done so. But the graduates of technical institutes in the United States are relatively few in number.

Engineering colleges have been preparing many men for sub-professional jobs in industry in spite of focusing their attention upon education of graduates for professional service. Many of their graduates have remained in subprofessional jobs. For every graduate, however, one or more non-graduates have been forced to leave college for financial or other reasons after attending one or two years only. Some of these non-graduates have reached the highest professional positions, but most have remained in subprofessional jobs. Engineering colleges in the United States have been serving industry as substitutes for technical institutes as well as professional engineering schools.

Experience indicates that the establishment of a large number of technical institutes would not relieve engineering colleges of this double duty. A few technical institutes for highly specialized training in certain industries should undoubtedly be established. But it would seem desirable for engineering colleges to recognize the conditions inherent to our democratic way of life and organize engineering curricula so that each year in college will prepare students for more responsible positions in industry as well as for more advanced engineering studies.

This philosophy of college education might apply to colleges of agriculture and of business administration as well as to colleges of engineering. Each year in any one of these colleges a student might prepare for greater responsibilities if he leaves school to earn a livelihood. If he is attending an agricultural college, he might be better prepared to become a successful farmer. If he is attending a college of business administration, he might be better prepared to engage in retail or wholesale trade, in insurance, in banking, or in some other form of business activity. If he is attending an engineering college, he might be better prepared for a job requiring technical knowledge and skill in manufacturing, in construction, or in a service industry.

The number of students who go to college for one or two years only will probably increase in accordance with past trends in school attendance in the United States. Thus, attendance in the first to fourth grades of the elementary schools increased from year to year until a maximum number was reached in the late twenties. From about 1930, attendance in these lower elementary grades has decreased by reason of fewer children being born each year in the United States. Attendance in the

upper elementary grades, from the fifth to the eighth, continued to increase and reached maximum numbers in the thirties due to elementary pupils remaining longer in school than previously. The crest of this tidal wave of school attendance reached the high schools in the forties. The world war distorted this tidal wave which is now engulfing the colleges with a greatly augmented crest due to returning veterans whose education has been interrupted by the war.

Many of these returned veterans will undoubtedly remain only a year or two in college. Conditions in industry will also favor high school graduates going to college for a year or two only.

Employees in industry were formerly recruited mainly from elementary school pupils who had to leave school and go to work in order to contribute to the family income. Present day foremen have been largely drawn from these older employees with a fourth to eighth grade education. Today many industrial employees are high school graduates. Foremen with only a grade school education are finding themselves handicapped in dealing with their better educated subordinates.

High school graduates in industry are in more favorable positions in the competition for promotion to supervisory positions than older employees with only a grade school education. More boys and girls will undoubtedly be sent to college for a year or two in order to place them in still more favorable positions for promotion to supervisory positions in competition with high school graduates. This industrial situation should be recognized by colleges of agriculture, business and engineering in arranging their curricula so that each year will prepare their students for more responsible employment as well as for more advanced study.

In law, in medicine and in theology, emphasis may remain wholly upon preparing graduates for service to society as professional lawyers, medical doctors, or ministers of the gospel. There are few subprofessional jobs open for a partly trained lawyer, doctor, or minister. Farming, trade, construction, and the production of manufactured goods, however, provide means of livelihood for most of our population. In these activities, all gradations of knowledge and skill can be utilized and are required, from the unskilled laborer to the highly trained technician.

Engineering has designated itself as a profession on a par with the older professions of law, medicine and theology. Engineers have codes of professional ethics, and highly trained engineers in responsible positions are devoting their skills to the service of society, as is the case with professional lawyers, doctors, and ministers. In many states, licensing laws have been established for registering professional engineers.

These licensing laws are based on professional attainments and require a minimum number of years of practical experience. College training may be counted in lieu of a limited number of years of practical experience, but the registered professional engineer need not be a college graduate. In fact registration as a professional engineer has been attained by individuals with no college education

On the other hand, many graduates of engineering colleges have never applied for registration. These graduates may be doing engineering work of high quality, but they have been employed by concerns which do not need regis-

tered engineers to meet any legal requirements. Registration of professional engineers was undoubtedly brought about to aid local governmental bodies in selecting qualified engineers for the construction of public works.

Thus, in the registration laws there is a distinction between a professional engineer and an engineering graduate. It is also widely recognized that there are many functional positions in industry requiring some knowledge of engineering techniques for intelligent thought and action although the work is not classified as engineering. When an engineering graduate accepts such a position, it is looked upon more as an indication of the wide range of usefulness of the engineering graduate to society rather than as a failure of his education and training.

Thus, engineering education has broader objectives than training students for service as professional engineers. Engineering colleges have recognized this fact in awarding the bachelor's degree for satisfactorily completing undergraduate engineering curricula and granting the professional degree only upon attaining professional standing. The need has also been recognized for "engineers prepared to practice at high scientific and creative level" by college training beyond the bachelor's degree.

It is only a short step in this recognition of varying levels of engineering education to organize engineering curricula so that each year in college would prepare students for more responsible positions in industry as well as more advanced study in college. Fortunately, this step involves but slight changes in the freshman and sophomore years of existing engineering curricula. Nothing needs to be done which is not now being done in some engineering schools. And such changes as might be needed in the freshman and sophomore years would improve the basis for further study in college as well as for immediate application in industry.

The Engineering, Science and Management War Training programs conducted under the sponsorship of the United States Office of Education demonstrated the qualifications needed in supervisory positions in industry. The experience in Nebraska is particularly enlightening because the problem here was to provide training for war production in a predominately agricultural region.

One of the first war training courses set up by the University of Nebraska was designated as Drafting and Shop Practice. It was a combination of freshman and sophomore courses in engineering drawing with courses in shop practice. The object of the drafting part of the course was to develop skill in making drawings as well as in reading drawings. The object of the shop practice part of the course was to impart a knowledge of production processes but not to develop skill in shop operations. Those who completed this early war training course found jobs in industries from the east to the west coast in drafting, in inspection and in other phases of war production.

Later, when a bomber plant was to be established in Omaha to be managed by the Glenn L. Martin Company of Baltimore, officials of this company were consulted as to how the University could aid them through war training courses. A large number of inspectors were found to be needed and the Drafting and Shop Practice course was modified into an Aircraft Assembly Inspection course.

Fortunately, the engineering draw-

ing courses at the University of Nebraska had been modified several years before the war to culminate in a course in Engineering Sketches and Working Drawings. Precision measurements had been introduced to determine the dimensions of machine parts sketched. This part of the course was found to need extension and additional measuring equipment was purchased as recommended by Martin Company officials. It was necessary to add a course in the physical properties of engineering materials including simple strength calculations and the effects of heat treatment and mechanical working upon metals. Discussions were also added on the organization of the inspection department.

Another enlightening war training experience was in connection with setting up a course in Production Planning for the Glenn L. Martin-Nebraska plant. At first, this course dealt with production planning principles. But those who completed the course were found deficient as employees in the production planning department because they could not read engineering drawings and they knew little about the physical properties of engineering materials. The course in Production Planning was therefore modified to place major emphasis upon reading engineering drawings and acquiring a knowledge of engineering materials and minor emphasis upon the principles of production planning.

Many other E.S.M.W.T. courses were set up to aid war production in this agricultural region. These courses demonstrated that the primary qualifications for supervisory positions in production are:

(1) Ability to read and often to make engineering drawings.

(2) Knowledge of shop processes.

(3) Knowledge of the physical properties of engineering materials.

(4) Knowledge of and preferably experience in precision measurements.

(5) Knowledge of human relations and ability to get along with people.

Inspection apparatus and methods have been highly developed in recent years, and their application was greatly extended during the war. Technical knowledge and skill are needed in inspection procedures. Many more graduates and non-graduates of engineering colleges will undoubtedly be employed in inspection in the future than has been customary in the past.

Employment in inspection will undoubtedly be a stepping stone to more advanced supervisory positions in production because the inspector has much greater opportunity to become familiar with production requirements and procedures in a whole department than the operator working at a single machine. The inspector should use tact in dealing with individual machine operators, and demonstration of this ability will put him in line for foremanship.

As an indication that more engineering graduates will be employed in production in the future, I would refer to a statement made by a representative of a well known company making electric motors. He remarked that before the war about ninety per cent of the engineering graduates employed by his company eventually entered sales work but after the war it was expected that a large number would be required to enter production.

Narrowly trained engineers avoid production. They do not realize the opportunities to reach management positions through the production route. In a certain well known company manufacturing automotive parts, it was necessary to force a mechanical engi-

neering graduate into a supervisory position in production by offering him the alternative of no job at all. Electrical and chemical engineering graduates were considered even more difficult to handle than mechanical engineering graduates. A broader viewpoint in the education of all engineering students would open opportunities to graduates and to non-graduates which are now denied to them.

Training non-graduates who must leave college after two years only for promotion to supervisory positions in industry through jobs in drafting, in inspection and in production planning, would be a valuable service both to industry and to the students concerned. This training would be equally valuable to graduates of four-year engineering curricula.

Returns from questionnaires recently sent to a large number of engineering graduates of the University of Nebraska gave Drafting and Testing and Inspection as the most frequent kinds of work required in the first job after graduation for mechanical, electrical and chemical engineering graduates. The character of the work gradually shifted through the years until managing stood out as the most frequent kind of work for older mechanical and electrical engineering graduates. Older chemical engineering graduates were found most frequently in research and development. Questionnaires were sent to all mechanical engineering graduates, to a large number of electrical engineering graduates, but only to a small number of chemical engineering graduates, so that the last mentioned returns might be biased.

Training for service in industry during the first two years of engineering programs need not detract from training for study of advanced engineering courses in the later years of engineering curricula. Courses in general chemistry and and physics should remain to provide basic facts and theories for application in industry as well as in advanced engineering courses. The usual series of courses in mathematics should remain as a tool for obtaining quantitative results in applying the facts and theories of chemistry and physics. Engineering drawing should be given an equal standing with mathematics as another tool for obtaining quantitative results. Graphical procedures are often preferred to mathematical methods.

Too often, engineering drawing is regarded as a subject to be completed in the freshman year without full realization of its importance in engineering practice, and particularly to the engineering graduate in his first jobs. At Nebraska, the engineering drawing courses have been extended through the freshman and sophomore years. In the freshman year, the objective is to impart an understanding of the fundamentals of projection including pictorial representation, provide a knowledge of drafting conventions, and develop techniques in drawing and lettering. Descriptive geometry is taught in the first semester sophomore and is followed in the second semester by a course in engineering sketches and working drawings. In the last mentioned course the student obtains experience in precision measurements and has his judgment developed in making and interpreting working drawings.

Courses in shop practice, preferably in which the student obtains first hand knowledge of fashioning materials, should remain in the freshman and sophomore years to provide that knowledge of production processes needed in supervisory jobs as well as in advanced

engineering courses discussing structures and machines, which must be built by such processes.

A course in engineering materials is necessary in the sophomore year to provide a knowledge of the physical properties of materials used in structures and machines. Such knowledge is required in supervisory jobs in industry and is also useful in discussions of structures and machines in advanced engineering courses. The course in engineering materials should be preceded by a course in engineering statics to give an understanding of force action as a basis for discussion of stress and strain in materials.

A course in industrial relations and supervision is desirable in the sophomore year to provide that knowledge of human relations necessary to get along with people in a supervisory capacity. Such a course is as desirable for students who remain in college as for those who leave before graduating for employment in industry.

Replies to questionnaires recently sent to engineering graduates of the University of Nebraska indicate that it is necessary to sell humanistic-social courses to engineering students as well as to teach such courses. If engineering students could be brought to realize the importance of human relations in their daily work as well as their daily living, this attitude might be changed. A course in industrial relations and supervision taught by an engineering teacher with industrial experience and the ability to maintain interest in class discussions, would serve as an introduction to an integrated sequence of humanistic-social subjects in the junior and senior years.

This proposal does not mean changing the first two years of engineering colleges into technical institutes. Nor does it mean lowering the standards of four-year engineering curricula by displacing fundamental courses in the first two years with vocational courses. It simply means supplementing the courses in general chemistry, physics, mathematics, engineering drawing and shop processes, usually included in the first two years of engineering curricula, with courses in engineering sketches and working drawings requiring precision measurements, in engineering materials, and in industrial relations and supervision, in order to fit the non-graduate better for the many subprofessional jobs in industry which are open to him.

Some schools are very close to fulfilling all these requirements in the first two years of their four-year engineering curricula. Other schools have much farther to go, particularly in industrial relations and supervision, in engineering materials, in shop practice and in engineering sketches and working drawings.

It is true that graduates of four-year engineering curricula must obtain employment in subprofessional jobs in order to secure the practical experience necessary to attain professional standing and registration. It is also true that such employment must often be obtained in competition with non-graduates. But this competition will continue to exist irrespective of how well or how poorly non-graduates are prepared for such employment. If the graduate is not better prepared than the non-graduate to meet such competition, then he has not gained much from the engineering courses in the junior and senior years.

Trends of school attendance in the United States indicate that a larger number of high school graduates will enter engineering colleges in the future

than in the past and that a larger proportion of these will leave before graduating from four-year curricula. While there is a present shortage of graduates due to the call of youth to war, this shortage will undoubtedly be converted into a surplus beyond the needs of industry to fill technical engineering positions.

For research engineers and designers, the technical requirements will be much higher than in the past by reason of advancements in science and technology, and more intense competition in meeting specified conditions as to cost, weight and performance of structures and machines. Graduate study in engineering or science will become an asset if not a requirement for research and design at high creative level. The needs for such highly trained engineers will be limited, however, so that only a few who have shown capacity as undergraduates to pursue graduate studies successfully, should be admitted as candidates for graduate degrees. That is, screening for graduate study should occur at the end of four-year undergraduate curricula and the great majority should be released with the bachelor's degree in engineering.

Many of these four-year graduates will eventually find employment as professional engineers in routine design, construction, maintenance, operation, testing and selling the structures and machines which make present day civilization possible, and the materials used in such structures and machines. A much larger number will eventually find employment in functional positions in industry where basic training in engineering is conducive to intelligent thought and action in the industrial environment.

More non-graduates than graduates will seek employment and will find subprofessional jobs in drafting, in inspection, in production planning, and in other supervisory capacities. There are several million such jobs in manufacturing and construction. Most of these supervisory jobs will be filled by promotion from the ranks. One or two years of college education should aid employees in obtaining promotion to foremanship in competition with high school graduates.

There is a natural point of division in engineering curricula between the sophomore and junior years—after the fundamental subjects of general chemistry, physics, mathematics and engineering drawing have been completed and before advanced engineering courses based thereon have been started. At the University of Nebraska, "a diploma of Associate in Applied Science will be awarded to students in the College of Engineering who have statisfactorily completed the first two years of any four-year curriculum in engineering. The training in chemistry, physics, mathematics, and engineering drawing required of all engineering students during their freshman and sophomore years fits them for minor positions in industry requiring applications of these sciences." This quotation is taken from the Bulletin of the Junior Division of the University of Nebraska.

Offering of this diploma makes screening possible between the junior and senior years. Only those who have shown by their scholastic standing in chemistry, physics, mathematics and engineering drawing that they are capable of doing satisfactory work in the engineering courses of the junior and senior years, should be admitted thereto. The remainder should be released with the Diploma of Associate in

Applied Science if they have passed the required freshman and sophomore courses.

Of course, many of those who leave before graduating from four-year engineering curricula, do so for other than scholastic reasons. At Nebraska, for example, two-thirds of the entering engineering students have dropped out of four-year curricula before graduating in spite of the fact that only one-fifth were in the lower half of their high school classes. Since nearly sixty per cent were in the topmost quarter of their high school classes, many of those who dropped out must have been qualified for more advanced studies.

Many dropped out before entering the sophomore year. The Diploma in Applied Science could be made an incentive to reach the objective of completing the sophomore year. For some jobs in industry, non-graduates who have completed only the first two years in engineering are preferred to four-year graduates. More non-graduates than graduates generally remain employed in local industries in the community where an engineering college is located.

A realistic technological education in a democracy should therefore provide for training at several levels to meet industrial needs without requiring stratification of society. Engineering colleges are now meeting these needs more or less satisfactorily by varying levels of training for graduates and non-graduates. To attempt to meet these needs by establishing a large number of technical institutes would necessitate stratification of society in order to force the children of certain groups into the technical institutes. Otherwise, past experience would indicate that the newly established technical institutes would in time become additional engineering colleges.

There is no doubt that a limited number of technical institutes can continue to provide vocational education at college level to those who wish this type of technological education. There is no doubt that a limited number of additional technical institutes could be established with advantage to industries in certain localities. But for general service to our industrial society, engineering colleges should give more attention to arranging their programs for training non-graduates for subprofessional jobs in industry as well as graduates for eventually reaching professional positions. This can be done with improvement in the quality of education for professional service.

Comparative studies demonstrate that engineering colleges now draw to their curricula the better minds in high school students. Observation shows that non-graduates as well as graduates fill many responsible positions in industry, functional as well as technical. As the portal between high school studies and industrial responsibilities, the engineering college occupies a position which requires engineering educators to take a broad view of their duties to society, beyond the training of professional engineers, if the engineering college is to render the maximum service to its community.

A Coordinated Program for Preparation of Engineering Technicians*

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This presentation might well be begun by referring to some of the terminology used in the general field or area implied by the title of this talk. While it is true that the occupational classification of "engineer" is subject to varied interpretations in different countries, different industries and in different localities, it is much more true that the listing of "Engineering Technician" as an occupational classification will be even more variously interpreted on the part of different individuals, and perhaps not interpreted at all by many others.

Who is an Engineering Technician?

A considerable number of somewhat similar terms have been used to identify workers in this general area of education and occupational activities. Among these are industrial technologist, industrial technician, engineering aid, engineering technician, while some have borrowed a suggestion from our armed forces and used the term "noncommissioned officer of industry." All of these terms carry with them an implication of the general area of activity engaged in by workers who are classified by these titles, although there is a considerable lack of definiteness or acceptance of the meaning in detail. As is often the case, preferences are expressed by schools, different industries, and different individuals, regarding the name that would best express the type of work expected from individuals that come under this general classification. For the purpose of this presentation, the term engineering technician will be used as best expressing the type of worker here discussed. An engineering technician, then, is a person qualified to serve in an area of activity between the tradesman or mechanical worker on one level and the professionally trained engineer on the other.

What does an Engineering Technician Do?

Opportunities for service by engineering technicians might be thought of as falling into one or more of several occupational groups as indicated by the following:

1. Managerial and Supervisory—as rendered by foremen in mass production industries, supervisors, production managers, plant superintendents, service managers, instructors in industry, liaison men, etc. Among industries furnishing opportunities for this type of work are: electrical, metal manufacturing,

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household appliance, automobile assembly and accessories, furniture manufacturing, building construction, printing, paper manufacturing. Those preparing to go into the field of service managing may look toward large oil companies, automotive service stations, or distributors of household appliances.

2. Technical Sales and Services—promoting and selling varied types of equipment and appliances, installing or planning and supervising installations of electrical and mechanical equipment, servicing technical appliances and mechanized equipment, or becoming independent proprietors of firms selling and maintaining equipment such as radios, refrigerators, automobiles, and various other types of mechanized household equipment. Modern emphasis upon this type of equipment should make this a promising field.
3. Technician Work, Inspection, and Testing—as typified by radio station maintenance, commercial radio work, automotive ignition and carburetion, power plant operation and maintenance, inspection and testing in mechanical and electrical industries, technical work in the printing industry, building trades, applied and ornamental horticulture, and many others.
4. Creative and Promotional Work—photography with emphasis upon industrial application, advertising layouts, display window design, use of visual aids in industry, drafting, production illustration, stage craft, printing, and publishing.

In all of these areas the job opportunity mentioned is ultimate rather than immediate, unless the individual has had extensive practical experience before taking his training in school. Obviously the young worker will be expected to start at some subordinate level of manipulative and operational work and then progress according to demonstrated ability and expanded opportunity.

How is an Engineering Technician Trained?

Institutions offering training to this type of worker are about as varied as are the titles of the workers themselves. Technical institutes are probably the most common of these. Such schools giving instruction to technical workmen above the vocational and manipulative level are relatively old institutions in the various European countries. In Sweden, four such schools were originated in the 1850's, while the same type of education became popularized in England in the 1870's. Other types of schools, the titles of which imply less differentiation in offerings than they do individual choice of expression, are mechanics' institutes, polytechnic institutes, polytechnic colleges, and institutes of technology. Institutes of technology, however, have generally elevated themselves into professional engineering schools, as in the case of the California Institute of Technology and the Massachusetts Institute of Technology.

In regard to length of courses and course offerings, it will be found that most of these institutions started with rather limited courses of study that were either organized to be given at suitable hours for workers who were on the job, or limited to one or two years for those who were taking the work as preparation for an occupation. It is probably true that the majority of schools now offering courses specifically designed to prepare workers in this area are still of the two-year

variety. They are represented by the number of junior colleges which have kept in mind this most important function, and by private and corporation schools in which work of this kind is offered.

More recently there has been a tendency to increase course offerings in this area in keeping with the general feeling that education should be prolonged for American youth and probably also because of the fact that many industries appear to hesitate to give promotion to technicians who do not have a four-year college degree. In California some junior colleges are doing outstanding work in this program, while others have apparently so far failed to take advantage of the opportunity of serving youth with a functional education in this most important field. The popularity of the program has caused many institutions to make announcements concerning offerings, while in many cases very little has been done to make the course effective and functioning. The passing of a legal enactment in 1934 by the California legislature enabling the State Colleges to expand the program outside of specific preparation for teachers, led to the adoption in many cases of four-year programs with technological emphasis, and in some cases to the announcement of "engineering" courses. Whether the four-year course as given in many institutions can truly be described as an organized program leading toward the education of an engineering technician or an industrial technologist will, of course, depend upon available facilities and competent instruction in connection with the work. A question has also been raised to what extent such a four-year course should attempt to be highly technical in nature, or whether it should be a general liberal education college course with a sufficient amount of technical offerings to give the graduate a salable skill in a narrow technical field.

Correspondence study and extension offerings furnish a definite service both in the original preparation and in the upgrading of personnel in this field. Correspondence work may be coordinated with institutional attendance with valuable results.

How Many Are Needed?

A number of studies have been made from time to time for the purpose of determining to what extent the technical institute graduate or the engineering technician is needed or wanted in industry. The results of questionnaires in large numbers sent to industrial concerns have indicated almost exactly the same ratio of this type of personnel to the total number of workers in the manufacturing industry. These figures indicate that from 2 per cent to 3 per cent of the total employees should be professional engineers, and from 6 per cent to 8 per cent should be the type that is produced by technical institutes of various kinds. This indicates that industry would absorb, roughly, three times as many engineering technicians as graduate professional engineers. From a study made in 1931 by Robert H. Spahr of the General Motors Institute it was pointed out that there was then needed for from 15,000 to 20,000 technical institute men a year in manufacture alone, with proportional opportunities in public utilities, transportation and others. Manufacturing methods and technical equipment developed since that time have probably increased the demand for the technical personnel in proportion to the number of workers because of the expanded use of production machinery

with increased problems of maintenance. Applied scientific and technical aspects of home and office appliances will also emphasize this increased need.

Conclusions

On the basis of these conditions, there seem to be some fairly clear indications leading toward the need for a well organized program nationally, and most specifically in California, toward the education of engineering technicians. The following points are suggested:

1. That opportunities in this field should be made known by program advisors and counselors in all high schools, and particularly in high schools in communities where junior college facilities are available. This, of course, implies that some organization or group of people should take the responsibility of furnishing informational material for program counselors for California high schools.
2. Courses in industrial arts in secondary schools, and particularly in senior high schools, need to be strengthened and so taught that the students will acquire necessary habits and attitudes of mind that will lead toward accuracy in technical and manipulative work as well as toward acceptable work habits and orderly procedures in working with tools, materials, and measuring equipment. Time alone spent in workshops and in courses in various phases of industrial arts work and vocational courses will not attain these ends. The burden lies largely with teacher training institutions in which teachers are prepared for this type of work, and which recommend their certification. What has been said here will apply also to courses given to students who plan to go into engineering programs for regular professional engineering courses. The type of drafting taught in high school, which is often useless as a preparation either for technicians or for engineers, might be cited as an illustration of this point.
3. There is definite need for a program of accreditation of technical institute curricula for junior colleges and other institutions offering this type of work. As reported in "California Schools" for February, 1946, a committee has been appointed for the purpose of assisting with curriculum details in this area. This committee is headed by Dr. Baldwin M. Woods, University of California; with Basil H. Peterson, Glendale Junior College, as secretary. Cooperative activities leading toward unified offerings and unified standards in connection with technical institute work for California will go a long way toward not only the increase of efficiency in connection with instruction, but the increase in the degree of confidence that men in business and industry will have in the technical institute product.
4. It would appear that the responsibility for a major part of the engineering technician training would lie with junior colleges in various communities in California. These communities can best serve the needs of the area covered by their school districts. Such a program would educate the young people largely for occupations that can be found in the home community and can give the education more economically, both from the standpoint of instructional

costs and from the standpoint of student expenses, than can schools located at more remote places. It must be admitted, however, that there are technical occupations which cannot profitably be represented in many communities, and in such cases area schools supported by combined school districts or state schools must be relied upon for the necessary instruction.

5. To what extent the educational program for engineering technicians should go beyond the junior college level might be subject to varied opinions. In general it might be true that a well organized program through high school and junior college would prepare young workers for a suitable entrance into industry at a suitable level with a background of both technical and general education which should enable them to succeed. There may be areas of technical work, however, in which the technical field is too broad and which require a larger amount of general college education than can be given within two years above the high school, but still not requiring a professional engineering course for the preparation desired. The fact that large industries and corporations are more and more inclined to expect college degrees from personnel in many fields that would be occupied by engineering technicians might also have to be taken into consideration, as well as the general tendency to increase the span of school attendance before entering upon a life occupation.
6. In occupational areas where a four-year college program would seem justifiable, there should be a limited number of collegiate institutions available in which the equipment and the teaching staff would be adequate for satisfactory work under the guidance of committees consisting of representatives from industry and labor with reasonable controls of numbers preparing for positions, according to possible rates of absorption.
7. Whatever the duration of the course of instruction might be, it should be considered important that, after the senior year in high school, the student should obtain some actual employment experience in the industry which he expects to enter. This could be done either by part-time and summer time experience, or by actual full-time employment for a school term or semester, thus prolonging his period of schooling, but making it more meaningful by practical experience. Such cooperative programs combining school work with alternate periods of employment experience are not new. They have been used over a considerable period of time both in connection with the training of technical workers and as a part of engineering education. The continued tendency toward increased specialization in the levels of technical employment would indicate, however, the desirability of stressing opportunities for work experience intermingled with school attendance whenever it is possible, in order that both types of experience may become most meaningful to the person who is preparing for this type of an occupation.

It should probably be pointed out that all persons who are concerned with the educational program for engineering technicians, whether it be counseling in regard to courses and future occupational opportunities, or actual instruction in the various subjects and

curricula, should assist the student to keep in mind that the training program and the career under the classification of an engineering technician are different from professional engineering. Course offerings in this area should not be calculated to give the scientific and professional training belonging to engineering curricula. The open and increasing field for personnel trained as here indicated should make it worthwhile for educational institutions to concentrate offerings directly toward training for the field of service suitable to the engineering technician. With this objective in mind, there is yet much that can be done in the post-secondary school field without attempting to cover the preparation of professional engineers for which only a few schools can hope to have adequate equipment and facilities.

The College Senior and the Small Industry*

By NICHOL H. MEMORY

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It has been suggested that engineering college placement officers must encourage small businesses to employ their seniors if the colleges are to continue to graduate their usual numbers of young engineers. One may disagree with the necessity and still agree with the desirability of increasing contacts with small industry, first, because all industry would benefit and second, because many seniors would prefer it.

The statement that small business furnished 67 per cent of the pre-war jobs is impressive. What proportion of small business employed engineers or could profitably have employed them is a question. More than 75 per cent of our seniors graduating from 1934 to 1942 inclusive, took their first jobs with the larger companies.

Perhaps this is a percentage common to most college placement officers who think in terms of careers for their seniors and not simply in terms of jobs. They know that a period of engineering apprenticeship is necessary for their young graduates and are concerned to see that employers are able to provide it. They know that many of their young men are capable eventually of finding their way into top management and they want to know that those opportunities lie ahead. The larger companies provide the means of training, either by formal courses, or because they have older engineers competent to supervise young men entering their employ. In the aggregate there ought to be more top management jobs for the young engineer to shoot for in small business than in large business, but whether this works out in practice is at least open to doubt. This is one point on which small business could afford to be explicit.

On the tables in the reception room of our combined admissions and placement office are to be found the printed financial reports, house organs, training programs and so on, of many large companies which together with their bulletins and catalogs on our college book shelves give a pretty complete preliminary picture to any interested senior. The national advertising of the "big name" companies has given them prestige and made their trade marks household words. One would say that the reputation of such a company would permit its college interviewer to sign seniors he wanted to employ on the dotted line and have an end of it.

As every engineering college placement office knows, the procedure is, in fact, time consuming and elaborate, including lectures, skilful individual interviews, and final consultation with deans and professors. Because visiting company personnel officers are on long established friendly terms with

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college administrators and faculties accounts in part for the ease with which the large companies make off with the seniors.

For the rest it can be said that few small company representatives take the trouble to lay the information before the senior or the college placement office that the large company furnishes as a matter of course. The fact is that few small company representatives ever appear in the placement office at all. They are content to make a telephone call, or to write a letter, and unless the enterprise is known to the placement office, usually because of Alumni connections, the inquiry receives scant attention. The following letter shows awareness of the situation:

"We are attempting to augment our personnel with some new blood, preferably technically trained, and believe that universities such as yours would be the most logical starting point to establish contacts with such individuals.

"In normal times we would select men who have been out of school for 3 to 5 years and have, so to speak, 'knocked off the rough edges' in the first stages of their experience with commercial activities as contrasted to school life. The conditions of war, have, of course, completely changed the possibility of adherence to such a program.

"Many schools have Student Employment Placement Bureaus. If such is the case at your institution, will you please see that this letter reaches the proper party. Otherwise, if you know of such individuals, or if they later come to your attention, may we have your cooperation in supplying us with their names and addresses.

"You, undoubtedly, will desire to know everything possible about any organization to which you might refer a young man for such an association. We will be very happy, indeed, to supply you with complete information of the company history, its ownership and management, its products, markets, etc., and anything else which you may feel will be of value to you in assisting us to select future members of our organization. We will welcome any suggestions you might care to give us, looking toward an improvement in our plan for doing so."

Skilful as large company interviewers are, they have no monopoly of personality or attractiveness to young men trying to choose their first jobs, and there seems to be no reason why the smallest enterprise, with the endorsement of the placement office, and with a friendly owner sincerely desirous of taking a young engineer into his business family, should not be successful in proportion to the opportunities it offers.

There are some reservations with respect to the placement of seniors with small business that can best be examined if the kind of jobs open to them and their potential capabilities for these jobs are roughly classified.

We have found it useful to think in terms of (*a*) research, development, design, (*b*) production, and (*c*) sales; an over-simplification, but one that has worked. In considering seniors believed to be qualified for research, development and design, recourse is had chiefly to their academic performance and the observation of those members of the faculty who have supervised their advanced work. This leaves much to be desired by way of appraisal, and the easy way out is to turn them over to the large companies having facilities and staff for training in still further advanced technical work. The placement office is then fairly certain that talented technologists will be developed and used at the highest level for which their education will qualify them.

This does not always work. The following is a quotation from a graduate

of six years' standing who has done exceptionally well in design and development with one of the largest companies in the field:

"My relations with my co-workers have been favorable, particularly those with the Chief Engineer and the Designing Engineer. The desire to change positions is composed of several points: (1) The compensation for my services has not corresponded with the responsibilities for several years, (2) I am decidedly uncomfortable in such a large company, where the 'security' angle is emphasized to the exclusion of enterprise. Quite frankly I am afraid that if I do not leave I shall become afraid to do so, (3) I have become so much interested in management and working with people that I wish to try my ideas and observation in more favorable locations.

"Specifically, I seek an opportunity leading towards management in a small manufacturing company, a position wherein the personal relations and the compensation are more nearly balanced and where paper work and routines are reduced to a minimum."

This is a forthright letter that has given its author a chance to blow off steam. The placement office, which shares the responsibility for having got him into his present job, is glad to provide the outlet. Perhaps that is beside the point. In any case, his analysis of his situation may not be wholly correct. That is open to investigation. His technical successes certainly have been made possible by the environment his company provided. What we should like to know is how to discover beforehand that such a man would be happy and still develop his talents starting with a small company. Every engineering college placement officer can look back over his alumni roster and spot graduates who have risen to heights of ingenuity and invention with resources of their own making. Until he can spot such a man in the raw, he is likely to continue to favor the employment of most of them by the large companies.

Still there would seem to be a large area in small business open to the exercise of engineering ingenuity. Moreover, there would appear to be no reason why a nearer approach to providing research facilities and engineering counsel comparable with that of the large companies should not be had by small business.

Certain special consulting and research facilities have long been available to business in general. A guess would be that big business makes more use of consulting engineers than does small business. There were, for example, a number of independent companies engaged during the war in doing overflow design and drafting work for large concerns. It would be interesting to know how many small businesses know of their facilities and how these companies fare in normal times.

It is believed that more engineering firms could be useful not only in highly specialized fields but in the common garden variety of engineering service for small manufacturing concerns at large, not only for the design and installation of special projects or for special studies, but for continuous check-up and handling of day-to-day engineering problems.

There has recently been organized a new engineering firm to serve small manufacturers in the process type of industry. In these times the firm finds it hard to expand its personnel fast enough to take care of the engineering business in hand.

Our placement bureau will do all it can to help make this new enterprise a success. It is headed by hard work-

ing, experienced men, capable of training cadet engineers, and it will afford opportunities for some of its young trained men ultimately to enter the employ of those small businesses that are its clientele. Half a dozen such outlets ought to be worth one hundred small businesses to any college placement bureau.

On the research side, certainly small business could make more use of the facilities and staff of the 150 existing engineering schools than they do. In some localities the local chamber of commerce or whatever its manufacturing counterpart might be could well consider whether having a financial stake in building up the research and consulting facilities of the neighboring engineering school would not be worth while.

Our rough classification mentioned above had for its second kind of jobs (*b*) production. Probably the majority of all engineering graduates end up in management work at one level or another. It is not difficult to discover those seniors with a gift for getting on with people. They rightly seek their first jobs in the plant. The larger companies encourage continuance of these young engineers' education, not only along the lines of production methods, standards control and so on, but in the field of human relations, having to do with employees, customers and the public in general. This education is usually furnished by the management of the company.

The senior entering the employ of a small business ought to be encouraged, and financially aided if necessary, similarly to keep abreast of his field. It is up to the proprietor of the small business to see to it that his young engineer belongs to the local section of the appropriate engineering society, that he has access to the technical magazines and books touching on his work, and that he takes advantage of evening graduate courses open to him. As he grows up his employer should encourage him to study accounting, marketing, and all that pertains to the business side of the enterprise. Such an attitude toward the young engineer on the part of small business men would surely enlist the interest of college placement officers.

Those engineering colleges operating on "cooperative" plans of employment and education should perhaps be the first to whom small business could profitably turn because of the opportunity afforded for a "trial marriage" of the engineering student and the plant. A second best is the job that can be made for the student during his summer vacation. It is worth doing even if it shows no apparent profit, and, incidentally, the college placement office will be the debtor. There are more requests for summer employment in large plants than can be conveniently handled.

In general it could be expected that college placement officers would look favorably upon the employment of seniors in small plants on the production side because the kind of young engineer who ought to be selected for any production job would be quick to adapt himself to the small organization and get on without resentment on the part of the old hands.

In the sales minded group, the third in our classification, the difference between a sales engineer and a peddler of engineering products also depends upon training. Engineering sales is a field often neglected by seniors competent to enter it. Many small companies sell their products through manufacturers' agents. The agent's office it-

self is an attractive small enterprise, subject to the same advantages and disadvantages of the small manufacturing plant in getting into top management. The chief complaint of the college placement officer is that the senior is too often sent out by the manufacturer's agent to contact the trade without the thorough grounding in factory methods, both manufacturing and servicing, that will put him in shape to hold his ground with older and wiser competitors. Many sales engineers make themselves useful to purchasing agents as "consulting engineers" and their calls are welcomed. A young sales engineer who does not have the training and ability to achieve this status will turn out to be a discouraged bell ringer and sitter in purchasing office reception rooms.

There seems to be no reason why small companies, or their agents, should not attract and hold the services of competent young sales engineers quite as readily as the large companies. The small company may make a better single kind of pump or furnace than the big one with a whole line of similar gadgets relegated to the status of a department. There is often less red tape involved in meeting special customers' requirements, and the chances for an alert sales engineer to best the big fellow should often be pretty good.

Perhaps it is the element of risk in small business that appeals to the sporting blood of certain young engineering graduates, if not always to the college placement officer. Within six months a quite recent graduate who had been in the sales organization of one of the largest manufacturing companies in the country, after three tries, succeeded in convincing our placement office that he really wanted to change to a small company for no other reason than just that. Didn't he like his present associates? Yes, very much. Wasn't he being paid according to his deserts? Yes, he had no complaint. Well, then, what was the matter? Only this, that if he were as successful as he had promise of and expected and intended to be, he could already see on the chart every job that he would eventually hold in the sales organization up to the District Manager, and he simply did not want to have his future staring him in the face.

Finally, there is the matter of human relationships in the large vs. the small company. Often the acquaintance with the large company college interviewer ends after the senior has entered the employ of the company. Sometimes it is continued. When it is continued it is all to the good, and the young engineer has a counsellor and guide in his formative years with the company.

In the small company this first relationship need never be broken. Instead it ought to grow and be strengthened. The sort of thing that is meant is illustrated by the experience of a senior seeking his first job who had been interviewed by the representatives of three companies in the same field. One of the company representatives arranged for a second interview with a company engineer at the plant to clinch the deal. This company engineer was an alumnus of the college. The senior's report to the placement office was that he chose that company because Mr. B., having graduated from his college, knew his background and would know how far and how fast to push him. This was a competent lad, but the best of them like to feel that someone will take a personal interest in them. The head of the small business can always supply this interest, if he will.

In conclusion it might be said that, of two equally competent seniors, the one who chose the large company would find himself adequately trained before called upon to accept real responsibility; would encounter stimulating competition within the organization and perhaps a rewarding position in top management; and if not that, almost certainly security and a satisfactory job.

The one who chose the small enterprise might have to see largely to his own training with perhaps a wider area of activity within which to exercise his wits. He would have to be alert in deciding when the path to progress had been barred to him and, if necessary, find a new job where he could keep going on up.

There are small enterprises that do provide opportunity for development and growth and for eventual participation in management and ownership for young men entering them. They are not always known to college placement officers. It is certain that such an enterprise would receive a warm welcome and all possible help in selecting young engineers.

Special Engineering Requirements of the Small Industry*

By GILBERT L. HARTMAN

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There comes a time in the life of every small industry when it emerges from adolescence and blossoms forth into a mature organization. This is not accomplished without the initial trials and tribulations of developing and promoting the sale of a product, and building up production capacity to satisfy an accelerating demand. It is during this building up period that it becomes evident that departments must be expanded and a definite plan formulated for the infiltration of new talent to keep pace with the growth of the industry, to provide for understudies to department heads, and to fill new positions created. Unfortunately, many small industries do not avail themselves of many opportunities open to them for obtaining suitable candidates to fill the newly created positions. They are not aware of the availability of engineering talent graduated from our engineering colleges every year or feel, perhaps, that they cannot compete with the larger industries who have, for many years, dominated the field of engineering graduate employment, and fail, therefore, to investigate the possibility of obtaining such talent.

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The Larger Corporations Dominate the Field

The larger and older corporations, such as General Electric, Allis-Chalmers, Westinghouse, Standard Oil, the aircraft manufacturers, and others, have done a splendid job of recruiting engineering talent directly out of the schools; they have also set up training programs designed to fit engineering graduates into the many jobs for which they are continually seeking suitable candidates. The officials of these companies are well known on college campuses through the prominence of their offices and active interest in the work of the Society for the Promotion of Engineering Education. This has contributed heavily toward the notion on the part of the officers and faculties of our engineering colleges that the large industries are representative of all engineering industries, in spite of the fact that the greater percentage of engineering graduates gravitate to the smaller corporations. The faculties, therefore, tend to assume that the scholastic requirements, standards, etc., of the larger industries must be the requirements of all industry.

Elaborate training programs have been set up by the larger corporations. They are willing to train graduate engineers over a period of 2 or 3 years,

which gives them an opportunity to study the ability and capacity of each student for the purpose of assigning him to research or other technical work, executive duties or other work for which he seems best suited. These students are not necessarily picked for any one job, but rather on a general basis, expecting that the training program will weed out the unfit and uncover talent usually not easily recognizable during the students' undergraduate work.

Can a Small Industry Compete?

Definitely! While it is true that a large industry has many openings for engineering talent and many separate departments which may be used for training purposes it is also true that the training must, of necessity, be highly specialized in each department. Compare this with a smaller industry in which there are fewer departments, but in which department activities and functions are more diversified than in the larger industries, where separate departments are organized. The student receiving training in such a department of diversified activities enjoys wider opportunities. For example, in a smaller industry the engineering department is, of course, in charge of all design work but also controls the activities of the experimental and research staff and, in some instances, may have control of inspection or similar functions. This gives the trainee the opportunity of observing the relationship between the several distinct activities which in many larger industries are separated and function under separate department heads.

Because the student in a small industry is exposed to a multiplicity of duties in any one department, his training may be accelerated. It may be adjusted to the needs of the company, allowing more or less time in the various departments in accordance with the immediate requirements of the employer, but it should also depend, to a great extent, on the adaptability of the trainee. The trainee's progress may be closely watched. Consequently the employer knows within a reasonably short time whether the student has the proper qualifications and can determine whether he can fill any one of the jobs which may be on the expansion list. Not only does the student have the privilege of an accelerated training, but he also has the opportunity of meeting and associating with the department heads and executives of the company.

All of these advantages give the small industry an edge in attracting suitable talent. It is an argument most students overlook in their desire to associate themselves with a large industry.

How to Obtain Suitable Engineering Talent

There is no one method for recruiting candidates which is most effective for any one company, nor for any one industry, nor for small companies as a group. Therefore, a recounting of experiences which have produced results in some cases may suggest a possible solution to any organization facing the problem of obtaining student engineers.

Probably the easiest and most direct method is to steal a page out of the book of a larger corporation by making the acquaintance (if it is not already a personal friendship) of a large corporation's personnel director or similar official for the purpose of studying the methods employed by him and discussing with him how some of these methods may be employed by the small or-

ganization. He is in position to advise which engineering schools are best able to produce the engineering talent required, the proper school officials to contact as well as the procedure to follow which will aid in a proper selection. To go one step further, it would not be out of order to request the privilege of accompanying him on a recruiting tour of several schools which would be of inestimable value in making the proper faculty contacts. Being introduced to such faculty members by one who has contacted them for years has the effect of producing immediate results because it more quickly elevates the contact to a more personal relationship between the faculty member and the interviewer representing the smaller company.

If conditions are such that it is not practical personally to visit the schools (although such visits are definitely recommended), the recruiting agent for the larger organization may volunteer to "steer" likely candidates in the direction of the smaller company. This approach is certainly not too effective but it is far better than allowing chance to dictate whether or not engineering candidates will seek employment with a small organization. Pre-selection by a personnel director experienced in such work may bring surprising results.

In some cases, contacts with university officials may be made directly rather than with outside help, but previous acquaintance with faculty members is then quite essential or it becomes necessary to cultivate such acquaintance. Because of specialization in mechanical, electrical, civil, chemical, and other fields of engineering, it is desirable to contact not only the officers of the engineering college, but also the department heads, professors or instructors who, in most cases, are intimately acquainted with individual students and know their scholastic accomplishments as well as their extra-curricular activities which frequently carry much weight in evaluating the student's qualifications for a definite job the interviewer has in mind. With the limited time at his disposal, the interviewer cannot, of course, interview all graduates; he will follow, to some extent, the suggestion of school personnel and interview the sudents recommended by them, and such recommendation will depend upon their knowledge of the interviewer's company, its product, past history and possibility of growth, and of the job to be filled. The interviewer will need to impart such information to the school authorities in considerable detail.

Up to a few years ago engineering colleges considered their job complete if their students were given an education according to prescribed standards, but lately the more progressive schools have taken the attitude that the job is not complete until their graduates have been properly placed. Usually this is accomplished by a college personnel director who makes it his business to contact industry, and since he is not personally acquainted with the students through classroom work, he has available sufficient information regarding each student to assist the interviewer in making his selection. This information is usually gathered in a card record giving a full description of the student; age, height, weight, etc., his parentage, his preparatory education, scholastic record in detail, his extra-curricular activities, what percentage of his educational expenses had to be earned by himself and much other pertinent information. A picture of the student completes the record. Such a record, properly kept up to date, even after

graduation, is of considerable value in the pre-selection of candidates to be interviewed.

One further step has proved very effective in the case of a small mid-western manufacturing plant. This company invited some of the professors of the mechanical engineering department of a neighboring college to visit the plant with expenses fully paid to become more thoroughly acquainted with the product, by means of a trip through the plant to see at first hand the production equipment in full operation, and to study briefly the production personnel set-up, the engineering department, and finally to meet top management and the executive group.

The immediate results to be expected from such a trip, even though it may be brief, are as follows:

(1) It gives the professors and instructors a far better picture of the type of organization for which they must prepare students.

(2) It makes for more intelligent recommendation of candidates.

(3) School personnel and industrial management become better acquainted.

(4) It promotes mutual assistance.

(5) The teaching profession gains a better understanding of manufacturing problems and, conversely, industry becomes more interested in the affairs of the university.

Unfortunately many of our professors have only an academic interest in engineering education and our industrialists are too busy with their own problems. These circumstances have mitigated against proper mutual acquaintance.

This acquaintance phase of the procedure may be termed the preliminary persuasion and conviction program which later must be continued with the candidate. The small company is usually at a disadvantage in competing with the larger company because the smaller company may be totally unknown and, as far as the student is concerned, the offer of the larger company is more attractive unless it can be proved that the smaller company offers the better opportunities. It is a selling job.

What Specifically Does a Student Want When he Leaves School?

That question cannot very well be answered satisfactorily because each individual has his own idea of what is important to him. It therefore becomes necessary to gather together sufficient data fully to describe the company and the opportunities offered, which may include the following:

(1) The company.
   a. Its history.

(2) The product.
   a. Where used.
   b. Present volume.
   c. Future expansion.

(3) The personnel in the company.

(4) The advantages offered by a small company.
   a. Job opportunities in the various departments.
   b. Job diversification.
   c. Advancement possible.
   d. Close association with department heads.
   e. Personal contact with top management.

(5) Salary.

Properly presented, the case of the small company will not suffer in competition with the larger company. A good selling job is necessary and the

results obtained are dependent upon the proper selection of a representative to do the interviewing. After selections have been made, a well planned training program will pay dividends in providing junior executives to fill new openings in a growing organization and eventually step into the shoes of retiring executives.

A gradual infiltration of suitable talent, properly trained, will minimize the danger of financial ruin or internal decay and will, without question, build up a sound organization.

Jet Propulsion—Its Effect upon Engineering Education*

By FRANK J. MALINA

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The title given to the collection of ideas that follow is indeed a presumptuous one, for at the present time a title punctuated with a question mark would be far more appropriate and descriptive. Until quite recently the words Jet Propulsion stood for the application in rockets of a long known physical principle. The challenge of the possibilities of the rocket was accepted by small stubborn knots of men scattered among the industrialized countries of Europe and America. The dream of these men was the conquest of space. The technical obstacles to the fulfillment of the dream that soon became evident, and the not infrequent scoffing of conservative scientists and engineers, caused many of the dreamers to resort to maladjusted extremism. There were, however, some among the "faithful" who realized during the last thirty years that jet propulsion in its many forms possessed unique characteristics which were immediately useful in the field of propulsion. As a result engineering skill was called upon to reduce to practice the basic principles of jet propulsion.

Before considering the effect of recent developments in jet propulsion on engineering education let us first analyze briefly the meaning of the term "jet propulsion," and the possible implications of this form of propulsion at the present stage of technological development.

It is customarily said that jet propulsion is the method of propulsion based on Newton's Third Law of Motion, *i.e.*, the principle of reaction. Although this statement is correct it does not specify jet propulsion with sufficient accuracy, since all forms of propulsion in a fluid depend on a force of reaction caused by the momentum imparted to a portion of the fluid. For example, the propeller of an aircraft or a ship provides a propulsive force by adding momentum mechanically to the fluid passing through the disk of the propeller.

For the purposes of our present considerations we can say that the term "jet propulsion" applies to those devices utilized for the propulsion of bodies that supply a propulsive force by ejecting matter from within the body being propelled. The propulsive force is obtained from the momentum added to the matter in the jet, and either this matter can be carried wholly within the body or a portion of it can be taken from the surrounding medium through which the body moves. A propulsion system of the first kind is known as a "rocket," and a device of the second kind is classified as a thermal jet pro-

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TABLE I

TYPES OF JET PROPULSION SYSTEMS

Rockets (No utilization of atmospheric air)	Thermal Jet Propulsion Systems (Atmospheric air or water utilized)
1. Solid propellent type	1. Compressorless, continuous thrust type: Ramjet (athodyd) in air. Hydroduct in water
2. Liquid propellent type	2. Compressorless, intermittent thrust type: Aeropulse (buzz bomb engine) in air. Hydropulse in water
3. Gas or vapor propellent type	3. Compressor driven by reciprocating engine, heat added to jet air from engine exhaust. Campini system
	4. Compressor driven by gas turbine, heat added to jet air and used as turbine working fluid before ejection. Turbojet system (Whittle)

pulsion system. In both of these systems we create momentum in the matter ejected by thermal or chemical processes.

The two classes of jet propulsion systems described above have also been applied to the propulsion of bodies under water. Nature provides an example of jet propulsion in the squid which is able to propel itself by taking in water and then by mechanical means ejecting the water opposite to the direction in which it desires to move. In Table I are listed the various types of jet propulsion systems whose characteristics are generally well known.

The rocket possesses two unique characteristics in the field of propulsion: that is, the propulsive force delivered is independent of atmospheric air, and thus is able to propel a body through empty space; furthermore it is unaffected by the velocity of flight. The rocket operates at an optimum when it is traveling in vacuum at a speed equal to the jet speed, which is of the order of 6,000 to 10,000 feet per second. On the other hand, the rocket consumes propellant at a higher rate than any other jet propulsion system. In spite of its voracious appetite it is able to compete with other systems in the atmospheric layer because it is a relatively simple mechanical device, and is capable of supplying a high thrust for a short period of time. For example, in the German V-2 missile the thrust horsepower supplied by the liquid propellent rocket at maximum speed is approximately 500,000 hp.

The solid propellent rocket, which is an outgrowth of the sky rocket and whose development is credited to the Chinese around 1200 A.D., was applied during World War II to air and underwater projectiles and used to assist the take-off of aircraft. The liquid propellent rocket was also developed to a high degree for applications requiring a longer period of thrust for the auxiliary propulsion of aircraft, the propulsion of a high speed interceptor aircraft, for example, the German ME-163, and the propulsion of long range missiles such as the German V-2.

The possibility of utilizing the liquid propellent rocket for sending instruments to high altitudes to investigate the physics of the upper atmosphere has long been the subject of considerable

interest. Recently the California Institute of Technology developed a sounding rocket, known as the WAC CORPORAL, which is capable of reaching altitudes above 200,000 feet.

In the field of aeronautical engineering, efforts are continually being made to increase the speed of aircraft. At one time it appeared that the speed of sound would be the upper limit, for when this speed was approached the conventional propeller was unable to supply the thrust required to overcome the drag of the aircraft. A solution of the thrust problem has been found in jet propulsion. We have already mentioned the possible use of the liquid propellent rocket to propel an aircraft; however, the high propellent consumption of the device limits flight to periods of very short duration. For flight in the atmosphere thermal jet propulsion systems are much more effective because air can be employed both as a major part of the jet mass and as a source of oxygen to burn fuel.

Of the thermal jet propulsion systems mentioned in Table I the possibilities of the turbojet and aeropulse are now public knowledge. Recently a turbojet propelled Army fighter plane, the P-80, flew nonstop from California to New York at an average speed of 584 miles per hour and during a portion of the flight a speed of 700 miles per hour was approached. During the last phases of World War II the inhabitants of London learned to dread the approaching sound of the German V-1, or buzz bomb, a winged pilotless missile propelled by the aeropulse.

Now that we have briefly summarized the salient features of jet propulsion from the point of view of the devices used and the applications made of them, we can ask the questions—"Why, when and how will engineering education be affected by jet propulsion developments?"

"Why will jet propulsion have an effect on engineering education?" All the examples of jet propulsion applications mentioned are essentially military in nature. If only applications to warfare were in sight, then we might be led to the conclusion that we should look for an effect of this development on political and social science, especially when it is realized that the combination of the atomic bomb with jet propelled missiles promises to put into the hands of man a weapon that has no effective defensive countermeasure.

The fact that modern total war requires the rapid application of scientific discoveries to weapons of destruction, and that peacetime methods of evaluation of usefulness lose practically all significance, causes the educator to be placed in a somewhat awkward position when the war is over, and plans must be made to prepare the engineering student adequately for the practice of his profession. The accelerating effect of war on the accumulation of special knowledge and on the development of special engineering methods is well understood. Some fields of research and engineering that are all but forgotten during peacetime are suddenly brought into prominence by the demands of warfare. Furthermore, the unfortunate lag during periods of peace between the accumulation of new knowledge on natural phenomena by scientists and its application by engineers is corrected usually by converting a large number of scientists into temporary engineers. Beginning with the Civil War, the government found it necessary to establish an emergency organization of scientists to bridge the gap between research and development. When the United States entered the

last war it established the Office of Scientific Research and Development which, in order to fulfill its technical tasks, was forced to call on scientists to practice the arts and skills of engineering as best they could. A number of engineering applications of the principles of jet propulsion were achieved in this manner.

It appears that jet propulsion will be called upon to perform several peacetime functions in commercial aviation in the immediate future. The first relates to the propulsion of aircraft at speeds that cannot be accomplished by the conventional engine-propeller combination. We are of course assuming that economic or philosophical justification can be found by man for transporting himself or his goods to a desired point in less and less time. If the engineer makes it reasonably economical to fly overnight, for example from the Pacific Coast to Paris, a sufficient number of passengers or quantity of cargo will probably be on hand to be transported. It is also not unlikely that domestic airlines will find a small fleet of very high speed aircraft profitable for carrying out flights of emergency nature. The thermal jet propulsion systems, which utilize atmospheric air, are most economical for the above aircraft, especially the turbojet type of power plant. The application of this power plant also can be expected to improve passenger comfort by reducing noise and vibration.

The rocket, mainly the solid propellent type, has demonstrated during the war the possibility of assisting the take-off of aircraft. Commercial airlines, even before the advent of the large aircraft now being constructed, encountered in their operations cases in which available airports were of insufficient length to permit take-off with full load. The feasibility of using rockets to overcome this difficulty is now being determined. The need for auxiliary rocket propulsion on large jet propelled aircraft appears to be certain.

In the realm of scientific research the liquid propellent rocket will undoubtedly be employed for carrying instruments to heights above the earth's surface that cannot be reached by any other method. Studies of the physics of the upper atmosphere and investigations of astronomical nature unhindered by the atmospheric veil will be undertaken.

When will jet propulsion have an effect on engineering education? A relatively large number of practicing engineers have already felt the impact of jet propulsion developments. Aeronautical, mechanical and chemical engineers particularly were suddenly confronted with new problems demanding satisfactory solution. In some cases known design procedures and construction methods have had to be extended, in others radical new concepts have had to be evolved. During the war, jet propulsion was one of the most closely guarded secrets, so that it has not been possible for those charged with engineering education to evaluate realistically the implications of its development. Now that the war is over, restrictions on the dissemination of information are being lifted, so that the public can obtain the maximum benefit from developments achieved through the use of public funds.

During the war a number of groups working on military applications of jet propulsion carried out educational programs to familiarize their members with basic principles and engineering problems encountered in this type of propulsion. General lectures on this subject were also given under auspices

of the Office of Engineering, Science, and Management War Training in areas that contained a concentration of industry interested in jet propulsion.

At the California Institute of Technology a graduate course in jet propulsion was initiated by Dr. Th. von Kármán in 1944 at the request of the Army Air Forces for the training of officer personnel. This course now requires a full year of instruction and plans are being made to open a graduate course to civilian students.

How will jet propulsion affect engineering education? We have already noted that the accelerated development of jet propulsion during the war has aided in stressing the need for engineers who can close the gap between scientific research and the useful application of its discoveries. The general tendency in the past has been for engineering schools to give courses which prepared the student for positions as constructing, designing, operating and managing engineers; that is, to make the engineer conversant with terminologies, techniques and tribulations of well established applications of natural knowledge to the products of industry. In many cases this educational process has produced the so-called "handbook engineer." Although industry still demands men who can be tagged with this classification, the men themselves are beginning to resent training which causes their technical horizon to be very limited.

At the present time the handbook engineer plays a minor part in jet propulsion because the devices utilizing this principle are still undergoing fundamental engineering modifications. Furthermore, developments in this field have brought to attention a number of technical subjects which are poorly understood in their fundamental aspects. It would not be incorrect to say that we are faced with a situation in which the engineer is pressing the scientist to supply him with special information on a number of important topics. In many cases the lack of this information is causing the engineer to resort to the purely empirical method of development, a method that during peacetime is difficult to justify, since it is usually very costly. To some extent engineering education is responsible for this state of affairs, for when the scientist was converted into a temporary engineer during the war, the flow of scientific information from him ceased or he was not available to answer the call for help when the engineer needed new aspects of physical phenomena to be investigated.

The applications of the principles of jet propulsion are at this phase of development hindered by a woeful lack of basic information on the following problems: chemical requirements for the rapid and efficient release of heat from the combustion of fuel with air and with chemical oxidizers; the interaction between fluid mechanics and chemical factors of combustion; heat transfer and cooling of mechanical components which utilize high temperature gases flowing at high velocity; physics of the solid state which determines the development of materials of construction capable of withstanding high temperature and corrosion; the behavior of a compressible fluid flowing through and around bodies of various shapes.

Without basic information on these subjects the development of jet propulsion devices is seriously handicapped. At this point the value of the research engineer needs to be stressed, for he can serve as the connecting link between scientific research and the final application of new knowledge for the

benefit of man. A research engineer would be expected to be the product of the highest type of engineering education, for he must be trained to appreciate the qualitative and quantitative factors that make up good engineering judgment, and he must be imbued with the spirit of disciplined analysis and of sensitive awareness to the implications of the results of scientific research. It is doubtful that men of this type will come from most of our engineering schools, even if the present curricula were modified to a small extent by increasing the stress on fundamentals.

Research engineers are playing key roles in jet propulsion developments. The range of problems requires the skills of aeronautical, mechanical, and chemical engineering, and especially a blending of certain phases of these three fields.

The solid propellent rocket introduces the chemical engineer to problems arising from the preparation of special types of combustible material which will meet requirements of burning under pressure in a uniform manner over a wide range of ambient temperature. In addition, these materials must have properties that permit hanling with a minimum of hazard. The mechanical engineer is called upon to provide light-weight high-pressure containers, which will also be capable of withstanding high temperatures.

The liquid propellent rocket, in essence, is a highly refined chemical supply system coupled to a rocket motor which converts the chemicals used into a high-temperature gas under pressure. Most of the chemicals now in use, for example, the oxidizers concentrated nitric acid, hydrogen peroxide and liquid oxygen, have to be handled under conditions very different from those under which they were manufactured. The requirements of high pressure pumps, gas turbines utilizing a working fluid obtained from the rocket propellant, and flow control equipment challenge the skill of the metallurgist and the mechanical designer. The rocket motor introduces the mechanical engineer to some of the most difficult problems of fluid mechanics, combustion, and design of components to withstand corrosion, erosion, and cooling encountered in any heat engine.

In the class of thermal jet propulsion systems, the compressorless type of device, although not recent in concept and on superficial consideration ridiculously simple from an engineering point of view, accentuates several fundamental problems of aerodynamics and combustion of fuel with air. The paucity of real understanding of the combustion process is startling, since engineers have applied this source of energy on such a large scale in so many different ways. The chemist and physicist acknowledge that reactions which occur during combustion are so complex that little headway has been made on the problem. We are told that the process of releasing atomic energy is already conceptually far clearer than the process of combustion. Since it appears that for many years to come engineers will use combustion as a primary source of energy, real vigor is needed to attack the many aspects of this process. In thermal jet propulsion systems the means and effect of adding heat to an air stream are of such importance that a new subject called "aerothermodynamics" has been introduced to the aeronautical, mechanical and chemical engineer.

The turbojet, which has an air compressor driven by a gas turbine, at the

moment appears as the most promising type of jet propulsion device in which air is mechanically raised in pressure before heat is introduced. The influence of this device in the design of compressors and gas turbines has already been felt, especially in stressing the possibility of increasing efficiencies by the proper application of aerodynamic and aerothermodynamic principles. For all airborne propulsion devices there is a requirement for minimum fixed weight; therefore, the turbojet has caused the mechanical designer to devise optimum means of utilizing materials for the construction of these components.

The brief summation of the problems encountered in the design of jet propulsion devices has shown us the close ties that exist between certain phases of aeronautical, mechanical and chemical engineering. Also it has been pointed out that at the present stage of jet propulsion developments the research engineer is in great demand. To meet the demand for this type of engineer, consideration has been given to the desirability of setting up a graduate course leading to the degree of Master of Science in Jet Propulsion Engineering. The California Institute of Technology is contemplating offering a Jet Propulsion Option in the Aeronautics Department leading to the degree of Aeronautical Engineer (Jet Propulsion). During the current academic year instruction has been given on the following jet propulsion subjects:

Aerothermodynamics
Chemistry in Jet Propulsion
High Temperature Materials
Rockets
Thermal Jet Propulsion Systems
Application of Jet Propulsion Systems
Jet Propulsion Research
Jet Propulsion Laboratory
Seminar

The desirability of establishing a new engineering degree should be subjected to careful scrutiny. Such a step would be contrary to the present trend to reduce the number of subdivisions in engineering curricula, and instead to stress fundamental courses at the expense of specialties. The jet propulsion enthusiast tends to feel that this development is of such broad significance that at least a year of graduate study devoted to this field is required before fruitful contributions can be made by the interested individual. Industrial organizations partaking in this development are applying pressure for training along these lines, and the military services are faced with the necessity of making a portion of their officer personnel intimately acquainted with the problems and possibilities of this method of propulsion.

It appears that jet propulsion developments have served, in some measure, to increase the present pressure for a careful evaluation of the curricula and general spirit of engineering education. The need for men trained as research engineers to aid in bridging the gap between scientific research and the useful application of new knowledge of nature has been critically appreciated by those given the responsibility for carrying out difficult phases of an urgently needed development during the war.

New Members

ADAMS, ORVILLE L., Technical Editor, Prentice-Hall Inc., 32 W. 40th St., New York City. W. J. Luzadder, J. N. Arnold.

APPLE, JAMES M., Instructor in Industrial Engineering, General Motors Institute, Flint, Mich. C. A. Brown, H. M. Dent.

BAIRD, JOHN, Assistant Professor of Electrical Engineering, Cornell University, Ithaca, N. Y. F. H. Pumphrey, J. W. Seiler.

BUSSARD, GORDON L., Personnel Div., E. I. du Pont de Nemours & Co., Wilmington, Del. G. O. Andrews, F. H. Chilton.

COLEMAN, GEORGE H., Dean, Institute of Textile Technology, Charlottesville, Va. H. O. Croft, E. B. Kurtz.

DAVENPORT, WILBUR B., Instructor in Electrical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. E. A. Guillemin, C. E. Tucker.

DOMAN, CARL T., Vice President and Chief Engineer, Aircooled Motors, Inc., 209 Parsons Drive, Syracuse, N. Y. H. W. Barlow, V. M. Faires.

DOTTERWELCH, FRANK H., Head, Dept. of Engineering, Texas College of A. & I., Kingsville, Texas. N. C. McGuire, F. L. Bishop.

FLINT, PAUL H., Assistant Professor of English, Tufts College, Medford, Mass. A. H. Howell, A. W. Leighton.

GATCHELL, O. J., Professor and Head, Dept. of Mechanics, U. S. Millitary Academy, West Point, N. Y. F. L. Bishop, Nell McKenry.

GRAHAM, JOHN W., Instructor in Civil Engineering, Carnegie Institute of Technology, Pittsburgh, Pa. F. T. Mavis, F. J. Evans.

GROVE, C. S., Professor and Head, Dept. of Chemical Engineering, State Univ. of Iowa, Iowa City, Iowa. H. O. Croft, R. M. Barnes.

HAMMOND, ROBERT H., Instructor in General Engineering, Purdue University, Lafayette, Ind. W. J. Luzadder, J. H. Porsch.

HOLT, JAMES, Associate Professor of Mechanical Engineering, Massachusetts Insitute of Technology, Cambridge, Mass. O. E. Tucker, R. H. Frazier.

KING, WM. JULIAN, Director, Sibley School of Mechanical Engineering, Cornell University, Ithaca, N. Y. W. N. Barnard, S. C. Hollister.

KLEIS, GUY, Supervisor of Engineering Training, Westinghouse Electric Corp., Pittsburgh 21, Pa. A. J. Murphy, H. W. Muller.

KNOWLER, LLOYD A., Chairman, Dept. of Mathematics, State University of Iowa, Iowa City, Iowa. H. O. Croft, F. M. Dawson.

KNUDSEN, HAROLD B., Dean, Professor of Civil Engineering, Chicago Technical College, 2319 W. 114th St., Chicago, Ill. F. L. Bishop, Nell McKenry.

KORGES, EMERSON, Assistant Professor of Engineering, Texas College of A. & I., Kingsville, Texas. N. C. McGuire, F. L. Bishop.

KUENSEL, HERBERT, Assistant Professor of Mechanical Engineering, Washington University, St. Louis, Mo. S. H. VanWambeck, F. A. Berger.

LARSON, ALVIN, Personnel Division, Goodyear Tire and Rubber Co., Akron, Ohio. T. W. Prior, F. L. Bishop.

LONG, J. WILLIAM, Administrative Engineer, Curtiss-Wright Corp., 21 Coolidge Ave., Caldwell, N. J. F. L. Bishop, Nell McKenry.

MALONEY, JAMES O., Professor and Chairman, Dept. of Chemical Engineering, University of Kansas, Lawrence, Kansas. S. A. Miller, J. C. Jones.

MATTSON, DALE W., Associate Professor of Civil Engineering, Tenneessee Polytechnic Institute, Cookeville, Tenn. J. M. Henderson, N. W. Dougherty.

MOORMAN, ROBERT B. B., Professor of Civil Engineering, University of Missouri, Columbia, Mo. Re-admission.

PLATT, WASHINGTON, Professor of Administrative Engineering, Syracuse University, Syracuse, N. Y. Louis Mitchell, S. T. Hart.

POWELL, RAY B., Staff Member, Personnel Dept., University of Californis Los Alamos Scientific Lab., P. O. Box 1663, Santa Fé, N. M. G. C. K. Johnson, F. L. Bishop.

ROBERTSON, FLORENCE, Assistant Professor of Geophysics, Institute of Geophysical Technology, St. Louis University, St. Louis, Mo. C. L. Wilson, E. W. Carlton.

ROGERS, PAUL, Assistant Professor of Structural Engineering, Chicago Technical School, Chicago, Ill. F. L. Bishop, Nell McKenry.

SANDSTROM, HERBERT E., Instructor in Mechanical Engineering, Michigan College of M. & T., Houghton, Mich. F. L. Partlo, W. A. Longacre.

SCOTT, RICHARD, Instructor in Electrical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. C. E. Tucker, R. H. Frazier.

SHAFFER, LYSLE E., Associate Professor of Mining Engineering, Missouri School of Mines, Rolla, Mo. C. L. Wilson, J. D. Forrester.

SMITH, CHARLES J., Graduate Student and Teaching Assistant in Civil Engineering, Carnegie Institute of Technology, Pittsburgh, Pa. F. T. Mavis, F. J. Evans.

UICKER, GEORGE B., Assistant Professor of Mechanical Engineering, University of Detroit, Detroit, Mich. S. T. Carpenter, M. B. Moore.

WALLACE, FELIX A., Instructor in Civil Engineering, Carnegie Institute of Technology, Pittsburgh, Pa. F. T. Mavis, F. J. Evans.

WEINBERG, LESTER H., Instructor in Civil Engineering, University of Akron, Akron, Ohio. R. D. Landon, B. W. Boguslowsky.

WIGHT, JOHN W., Associate Editor, McGraw-Hill Book Co., 330 West 42nd St., New York City. H. P. Graves, J. S. Thompson.

ZMOLA, PAUL C., Instructor in Mechanical Engineering, Purdue University, Lafayette, Ind. A. S. Hall, R. C. Binder.

38 new members this year

Sections and Branches

The 1946 Spring Meeting of the **Middle Atlantic Section** was held May 11, 1946, at The Engineers' Club of Philadelphia, Pennsylvania. The meeting was jointly sponsored by The Engineers' Club of Philadelphia, and the Philadelphia Sections of the American Institute of Electrical Engineers and the American Society of Mechanical Engineers. The total attendance at the meeting was 167, including 33 women. Twenty-five educational institutions were represented and 18 industrial organizations.

The morning session was given over to an inspection of the laboratories of the University of Pennsylvania and in particular to a demonstration of the Electronic Numerical Integrator and Computor and Differential Analyzer at the Moore School of Electrical Engineering.

Chairman C. D. Fawcett (U. of P.) called the meeting to order at 2:00 P.M. Walter C. Edge, President, Engineers' Club of Philadelphia, expressed the pleasure of the club and associated societies in being host to the Section. The minutes of the December 1944 meeting of the Section were read and approved. The secretary stated that no meetings of the Section were held during 1945 owing to war restrictions. He further stated that the officers elected for 1945 were still in office subject to the desires of the Section. Upon motion the officers were continued for 1946. The officers for the year 1946 are therefore:

Chairman—C. D. Fawcett—University of Pennsylvania
Vice Chairman—J. C. Elgin—Princeton University
Secretary-Treasurer—F. D. Carvin—Newark College of Engineering.

The Chairman appointed the following committee to place in nomination officers for 1947: Chairman—J. H. Billings, Drexel Institute; J. S. Morehouse, Villanova; Moreland King, Lafayette. This committee will report at the December 1946 meeting. The treasurer reported a balance on hand as of May 6, 1946, of $408.10. The balance includes the contribution of The Engineers' Club, the A.I.E.E. and the A.S.M.E. towards the expense of the present meeting.

During the past few years, meetings of the Section have been held under the sponsorship of industrial organizations instead of on college campuses. The Chairman appointed the following committee to make recommendations as to our future policy in this respect: Chairman, G. F. Bateman, Cooper Union; S. J. Tracy, College of the City of N. Y.; M. Bailey, Rensselaer. The committee reported at the evening session that we should continue our present policy of industrial sponsored meetings for the next year and, after that, to return to meetings sponsored by educational institutions. It was further recommended that a standing committee on meetings be appointed for a five-year period. The Chairman, therefore, appointed the above committee to serve as a Committee on Meetings for the next five years.

The topic of the Technical Session was Mutual Objectives of Engineering

Faculties, Students, Societies, and Industry. The first speaker was John M. Fogg, Jr., Vice-Provost, University of Pennsylvania. Dr. Fogg's topic was, Faculty Participation in Research and in Consulting Practice. Dr. Fogg in general defined the policy of the University of Pennsylvania in regard to research and consulting practice of the Faculty. In his opinion the undergraduate school should be devoted entirely to basic instruction, while the graduate departments specialization and particularly, research activities should be encouraged. A teacher should be rated for advancement based on definite evidence of his ability. This evidence should be in the form of his teaching record, his research activities, and, in engineering in particular, his professional consulting activities. He intimated that in engineering colleges the faculty has a definite service to perform for the public, especially if they are specialists in any particular field. Their consulting practice should be solely controlled by them as teachers, provided this practice did not interfere with their teaching schedule. They should have free use of the laboratory for their work. If they have an outside consulting office such activities should not take more than one day a week from their teaching schedules. He feels that such activities are a real benefit to the school and to the community. He also emphasized the danger that might occur if such activities were in competition with other consultants or professional organizations. In general the teacher should work in a field where he has specialized knowledge. Further, due to the salaries paid teachers, it is necessary for them to increase their income by professional activities. He thinks that members of the faculty who engage in consulting work make better teachers. He feels in particular, that engineering teachers, due to their specialized skill, should make their services available to the public.

The next speaker of the technical session was A. R. Stevenson, Jr., Secretary, Engineering Council, General Electric Company. His subject was Mutual Objectives of Engineering Faculties, Students and Industry. Dr. Stevenson in general discussed the needs of the industry as exemplified in college graduates. He emphasized three points in particular: One, function of the college to develop analytical ability in the student; second, the development of creative ability; and third, training for leadership. In regard to the first phase, analytical ability, he thinks the colleges are doing a very fine job. He recommended that the undergraduate program should stick to its basic training, leaving specialization to the graduate school. He emphasized the fact that industry should not expect the college graduate to be a professional engineer. In regard to the second and third phases, creative ability and leadership training, he thinks the colleges are doing a relatively poor job. There is practically nothing in the present curriculum tending to develop creative ability, and very little to develop leadership qualifications. He recommended that college instructors should obtain more practical experience and suggested a program similar to that of medicine, where a young teacher should serve an internship in industry either before he begins his teaching profession or concurrent with it. Unless teachers have the industry's slant they cannot properly train undergraduates. He think colleges should be more liberal in granting sabbatical years and that the faculty take advantage of the sabbatical year to increase their indus-

trial experience. He suggested some kind of an exchange program set up between industry and the college whereby industrial engineers and college faculties should be interchanged. In answer to a question on the unionization of technical men, he expressed himself against such a move. He favored a large spread in pay rates for engineers and favored the incentive system. He stated that his impressions were that unionization tended to level off all groups in certain categories and that destroyed their initiative.

The third speaker was Harry W. Pierce, Past-Chairman, Technical Societies Council of Philadelphia, and associated with the New York Shipbuilding Corporation. He spoke on the subject, Mutual Objectives of Engineering Faculties, Students and Societies. Mr. Pierce stated that one of the main objectives of the Societies was to continue the education of the engineer. The function of the college is to give a basic training in the engineering field, and the function of the Societies is to fill in the details of the professional aspects of the work. He felt that the Society should lead in the economic phase of engineering and commented favorably on the program of the Engineers' Council for Professional Development. The Society should lead in stimulating the engineer in civic activities and public work and, further, take a leading part in promoting the economic development of the engineer.

The afternoon session adjourned at 5:00. During the time between five and six o'clock, the Section had a social hour in the Engineers' Club. Dinner was served at 6:00. At the dinner meeting Chairman Fawcett expressed the appreciation of the Section for the hospitality rendered by the Engineers' Club of Philadelphia, the Philadelphia Section of the American Institute of Electrical Engineers, and the Philadelphia Section of the American Society of Mechanical Engineers. He also thanked the various speakers for favoring us with their attendance.

FRANK D. CARVIN,
Secretary, Middle Atlantic Section, S.P.E.E.

The Tenth Convention of the **Pacific Northwest Section** was held at the University of Washington May 10 and 11. This was the first meeting since the spring of 1941, and was participated in by all Engineering Colleges in the Northwest except Gonzaga. The attendance was as follows:

Oregon State College	15
Washington State College	9
University of Idaho	9
Montana School of Mines	1
Montana State College	1
University of Washington	30 (approx.)

The figure for the University of Washington is the average of the attendance at the technical sessions. Dean F. M. Dawson of the University of Iowa, who happened to be visiting in the Northwest, attended the meeting and contributed to the discussions. He also told us about the work of the Engineering College Research Association.

The new officers of the N. W. Section are from Washington State College, where the 1947 meeting will be held.

Chairman	F. W. Candee
Vice-Chairman	D. E. Aldrich
Sec.-Treas.	L. B. Almy

ERNEST D. ENGEL

The **Northeastern University** and **Tufts College Branches** held a meeting at Northeastern University, Boston,

Massachusetts, on April 27, 1946, in which they acted as hosts to delegates from most of the colleges of the New England Section—attendance, 80.

The various committees met in the morning to plan for the 1946 Fall meeting of the Section to be held at Norwich University. After a luncheon the delegates assembled under the chairmanship of Professor L. F. Cleveland of Northeastern University to hear Homer L. Dodge, President, Norwich University, discuss The George Westinghouse Award in Engineering Education. Following this talk H. S. Rogers, President of S.P.E.E., gave a complete history of the proposed revisions in the Constitution of the S.P.E.E. Dr. Rogers answered all questions in the forum which followed this discussion.

The two college branches held a short business meeting prior to the speakers in which the following offices were elected:

Tufts College

Arthur W. Leighton ... Chairman
Frederic N. Weaver .. Secretary

Northeastern University

Lawrence F. Cleveland .. Chairman
Ernest L. Spencer .....Secretary

ERNEST L. SPENCER

College Notes

California Institute of Technology. Recent changes which have taken place at the Institute are Lee A. DuBridge elected as President of the California Institute of Technology succeeds Robert A. Milikan who is listed as Chairman of the Executive Council.

Frederick C. Lindvall succeeds Franklin Thomas as Chairman of the Division of Engineering.

A. P. Banta has just been appointed as Associate Professor of Sanitary Engineering of the California Institute of Technology on full time basis. He just recently returned from the Pacific Area where he was Lieut. Colonel, Corps Engineers.

G. W. Housner has been appointed Assistant Professor of Applied Mechanics. Dr. Housner was with the District Engineers Office in Los Angeles in Structural Analysis before the war.

Case School of Applied Science. Robert L. Shurter has been appointed Professor and Head of the Department of Language and Literature succeeding Professor Karl O. Thompson who is retiring from his administrative duties as department head but will continue as a member of the teaching staff. Professor Thompson has been a member of the Case faculty since 1914; he has served as a department head for the past twenty-nine years and as secretary of the Case faculty for sixteen years.

Other promotions to the rank of associate professor include Daniel K. Wright and Gayle B. Priester in the Department of Mechanical Engineering and J. Reid Shelton in the Department of Chemistry. Raised to the rank of assistant professor were William E. Umbach of the Department of Language and Literature, Erwin F. Shrader in Physics, Louis J. Green of the Mathematics Department, and Lawrence G. Seigel of the Mechanical Engineering Department.

New instructors appointed are H. V. Caldwell, Jr., in English, Ladis D. Kovach, Mathematics, and Sherwood Fawcett, Physics.

Colorado School of Mines. James Boyd has been appointed dean of the faculty of the Colorado School of Mines, Colonel Boyd has been directing industrial operations in the American zone of German occupation as a deputy to Lieutenant General Lucius D. Clay. He has been specially charged with the direction of all industrial operations except those relating to iron and steel. He recently represented the United States in the four-power negotiations regarding the status of industry in Germany after the withdrawal of reparations. For his work in Germany he has been awarded the Oak Leaf cluster to the Legion of Merit award.

The new dean is a graduate of the California Institute of Technology and received the doctor of science degree from the Colorado School of Mines in 1934. He was a member of the faculty of the department of geology at the Colorado School of Mines until 1940 when as associate professor of geology he took a leave of absence to become chief of the metals office in the office

of the undersecretary of war. He directed production control for supervisory headquarters of the allied expeditionary forces and for the forces of the United States in the European theater.

The College of Engineering at the **University of Colorado** is anticipating an enrollment of 1,600 students in the Fall term, which is exactly double that of pre-war days. To take care of this increase, Dean Clarence Eckel and his staff are working hard to find teachers. So far thirty-five new members have been added to the engineering faculty, with many more vacancies to be filled. These men are being recruited from both industry and the armed services. In spite of the great demand for teachers, Dean Eckel reports that his department heads have been fortunate in securing many excellent men with valuable experience in the business world, in research, as well as in colleges. Some of them are as follows:

Lt. Col. Harold W. Sibert, adviser for the Army Air Corps on technical problems of aerodynamics, has been appointed professor of aeronautical engineering, to help Professor K. D. Wood, head of the newly organized Aeronautical department. Sibert was professor of aeronautical subjects at the University of Cincinnati before entering the army.

Also added to the aeronautical staff is Capt. Allen R. Deschere, of the army ordnance department at the Aberdeen Proving Grounds. He holds a master's degree from Lehigh University and worked for three years with the Du-Pont Company at Penns Grove, N. J.

Joining the Chemical Engineering department staff is Professor Byron E. Lauer, who has a Ph.D. degree from the University of Minnesota. He also has been in the army, serving as lieutenant colonel in the Chemical Warfare Service. He has had considerable experience as research chemical engineer with various companies before the war, and has extensive publications on his studies.

The Electrical department has secured five young men with valuable experience in the armed services and industry. They are Willis Worcester, Harris Thompson, John Twonbly, William Hanna, and Marion Smith. Professor Smith returns to Colorado after having taught for three years at the Rice Institute. Before that, he was with the Reclamation Bureau in Denver.

The Mathematics department has added nine men to the staff; but Professor Hutchinson, the head, states that altogether twenty new teachers will be needed. Besides the new instructors are Professor Karl Stahl and Commander Vincent Moore. Professor Stahl has a Ph.D. degree from the University of Pittsburgh and has been head of the Mathematics department at State Teachers College in California, Penn. Commander Moore is well known in Denver, where he engaged in business many years before going to the University of Colorado as an executive officer in the various Naval training schools during the war.

The consolidation of three departments of instruction at **Missouri School of Mines and Metallurgy** into one department to be known as the Department of Humanities and Social Studies was approved. Professor S. H. Lloyd, presently Professor of Economics, will head the new department. The new department will offer courses in English, Economics, History, Sociology, Psychology, and Foreign Languages.

The purpose of the consolidation is to make more effective the recommendation of a committee of engineering educators made in 1940 concerning engineering education after the war. This committee suggested that the equivalent of about one academic year be allotted to the area of humanities and social studies to augment the technological education of the young engineer.

Professor Lloyd has been on the faculty of the School of Mines since 1921 and Head of the Department of Economics since 1938. He is a graduate of DePauw University and has a Master's Degree from the School of Mines. He will be assigned the task of integrating the work of these various departments and planning the broad program to make the work of these departments fit more nearly into the general recommendation of the committee of engineering educators from the American Society for Engineering Education as mentioned above.

Professor Lloyd stated that the primary objective of the new department would be to develop the ability of the engineering student to read, write, and speak the English language effectively and to give him a knowledge of human social relationships and an understanding of the duty of citizenship and an appreciation of the cultural interests outside the field of engineering in order to broaden the view of the young engineer in meeting his responsibilities in the tremendous technological developments which this country is witnessing and the even greater developments that seem certain to come with the passing years.

Professor R. Z. Williams, Chairman of the Mechanics Department, has been appointed Assistant Dean. The appointment was made necessary by the greatly increased enrollment expected at the School of Mines this fall.

Professor Williams graduated from the Missouri School of Mines and Metallurgy with the degree of Bachelor of Science in Metallurgy in 1931 with highest honors. He joined the Missouri School of Mines faculty as instructor in Mechanics, and later took his Master's Degree in Mechanics from the University of Wisconsin. Since that time he has earned the degree of Bachelor of Science in Civil Engineering here, and has done additional graduate work at the University of Michigan.

While still an instructor, Professor Williams became interested in the so-called filled-sink deposits of iron ore in the Missouri Ozarks, and in 1934 in one of these mines he located a deposit of iron pyrite. Since this mineral was in demand for the production of sulphuric acid, the deposit was developed by the partnership of Thomas and Williams, and subsequently became the largest pyrite producing property in Missouri's history.

Professor Williams was made full Professor of Mechanics in 1945, and served as Acting Dean of the school during Dean Wilson's absences from the campus in 1945 and 1946.

Texas A. & M. College. S. R. Wright has been appointed head of the civil engineering department, and remains acting head of the municipal and sanitary engineering division until a replacement can be found. Arne A. Jakkula, noted bridge construction expert, has been chosen head of the Texas A. & M. Research Foundation, organized to provide research facilities for industry and agriculture. Among new faculty members are Walter Torgersen and Jack CoVan in management engineering, R. L. Whiting in

petroleum engineering. Civil engineering lost two professors, T. A. Munson going to Dow Chemical company and Howard Hansen to the University of Florida. The following promotions in rank are announced: John P. Oliver, Assistant to Associate Professor; C. H. Ransdell, Assistant to Associate Professor; B. F. K. Mullins, Assistant to Associate Professor; G. H. Brock, Assistant to Associate Professor; R. L. Barton, Instructor to Assistant Professor; B. M. Gallaway, Instructor to Assistant Professor; Charles T. Hatchett, Instructor to Assistant Professor; L. E. Stark, Instructor to Assistant Professor.

University of Vermont. Professor Edd R. McKee, who for the past year has been acting Dean of the College of Engineering, has been appointed Dean of the university's new College of Technology.

Born at Indianola, Iowa, March 9, 1898, Dean McKee attended schools in Indianola and in Long Beach, Calif. He received his B.S. in E.E., his M.S. in E.E., and his E.E. from Iowa State College He was instructor of electrical engineering at the same college from 1921 to 1925, and associate professor from 1925 to 1934. During the summer vacations he was employed as assistant electrical engineer by the General Electric Company, by the Automatic Electric Company, by the Underwriters Laboratories, by Northwestern Bell Telephone Company, and as research engineer for the Iowa Engineering Experiment Station.

Before coming to Vermont in 1934 as head and professor of electrical engineering, he was for a year technical advisor to the Iowa State Planning Board.

Return to the Secretary, F. L. Bishop, University of Pittsburgh, Pittsburgh 13, Pa.

AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Date .....

I desire to become a member of the

AMERICAN SOCIETY FOR ENGINEERING EDUCATION

and hereby agree to conform to the requirements of membership, if elected, and submit the following

STATEMENT OF QUALIFICATIONS:

Full Christian Name and Surname .....
PRINT LAST NAME FIRST MIDDLE

Mailing Address (Number and Street) .....

Post Office (City and State) .....

Full Title of Professional Position .....
(TITLE) (DEPARTMENT)

Full Name of Institution .....

(To be signed by Two Sponsors)

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